The Manual For G.P.S
With Conventional
Non-Electronic Maps

There are two things your other GPS manual
did not tell you!

1. How to find a G.P.S coordinate for anything on a paper map.

2. How to use your G.P.S to locate your position
 on a paper map

The Manual For G.P.S With Conventional Non-Electronic Maps

By Robert Kiser

Warning!

The author and the publisher assume no liability for accidents or injuries of persons or property of readers who engage in the activities described in this book. For your personal safety please read the section on

The Manual For G.P.S With Conventional Non-Electronic Maps

The Manual For G.P.S With Conventional Non-Electronic Maps

I bought my first G.P.S in 1996. I was just starting to plan a hike on the Pacific Crest Trail across Oregon. This is a trail that travels along the West coast from Mexico to Canada. It did not take me too long to realize that the manual that came with my G.P.S lacked the information I needed. The manual was designed to help me back track or find my way back to where I had already been. Hiking this trail I had no interest in finding my way back. I was only interested in finding my way to somewhere I had never been before. I knew that possibly there would be times when I would lose the trail in snow, windfalls, washouts, etc. Looking at the maps that I would be using I also realized that there were some long stretches in-between water sources. Yet there were creeks nearby that did not cross the trail. How would I find them? I also knew that there would be times when I would be on the trail and would like conformation from my G.P.S as to where on the map I actually was at the moment. Unfortunately my manual did not tell me how to use my G.P.S in this manner. So I bought a thirty-dollar book on navigating with a G.P.S. I learned a lot from this book, but the bottom line is it did not teach me how to do what I wanted to accomplish either. I was very frustrated and had to figure it out on my own.

Since, that time manufactures have developed different versions of G.P.S receivers that cost more. There are also electronic maps that you can buy that can be downloaded into your G.P.S receiver. This certainly makes some things more convenient yet I still see the need for my book. You could rely only on the most expensive G.P.S and electronic maps if you want. However, I can still see two problems. First, all maps are not equal. I have found one map may be more reliable for finding water sources another map will show more trails.

Another map may show more roads. In other words some maps will show certain features better than other maps. I don't want to say I can't use my G.P.S receiver to go there just because the location is found on a paper map and not on an electronic map. The second reason is only so much detail can be shown on a little hand held screen on your G.P.S receiver. Therefore, you cannot see all of the surrounding detail at a glance as you can on a conventional map.

By utilizing the information in this book you can use any map that has latitude and longitude degrees marked on the side. With this information and a little math you can enter Waypoints into your G.P.S receiver.

In this way you can utilize all your favorite maps that show the detail you want to see. (Not to mention that you can save money by not buying stuff you do not need.) With the information in this book you will also be able to find your current location on your favorite map using your G.P.S receiver. I can go anywhere I want and locate myself on the map using the cheapest G.P.S receiver without paying extra for electronic maps.

A Waypoint is a coordinate or location that you enter into your G.P.S receiver. I am assuming that you have already learned how to use your G.P.S to enter and find Way Points. The manuals that come with a G.P.S do a good job of teaching you that much.

You do not need a G.P.S to learn how to get a G.P.S coordinate from a map. This book will make much more sense, if you treat it like a workbook and follow along with the steps locating Dollar Mountain using the map at the back. You may even want to photo copy that page so you can easily work with the map without having to turn back and forth in the pages in the book.

T **Understanding the format of this book.**

You will notice that throughout the book that some things are labeled as:
3a, 3b, 3c or 4a, 4b, 4c, etc.
The number is for the chapter.
The letter is for the step within the chapter.

Some more involved chapters include a checklist. The checklists are there to help you remember the order of each required step to perform the task at hand. You may want a reminder of the order of each required step without having to read again how to do each required step.
The checklists are also labeled 3a, 3b, 3c or 4a, 4b, 4c, etc. These labels directly correspond to the explanation of how to do each required step for that particular task.

Using this book

Click on the "T" in the box of the upper left on any page to take you back to the Table of Contents.

From the Table of Contents you can click on any section of the book that you wish to read,

Table of contents

CHAPTER 1

There is general information that needs to be understood about the map and your G.P.S.

You will need a map that has the Latitude and Longitude coordinates along the edge of the map. These are the lines that you have seen on a globe. These numbers on a map are expressed in degrees, minutes and seconds. These are not measurements of time. They are measurements of distance. One degree of Latitude is equal to 60 minutes or about 69.17 miles. One minute of Latitude is equal to 60 seconds or about 1.15 miles. One second of Latitude is equal to about 33.82 yards. Longitude does not remain consistent. The reason why is because the circles around the globe become more compressed as you go North or South of the Equator. They become compressed because the world is spherical or ball shaped in design. Having given you all of these measurements I should also tell you that these measurements are a surveyed distance. It will not be that exact on your G.P.S. receiver. I have had my receiver indicate that I changed my location by a second or two when in fact I had not moved at all.

Reading these latitude and longitude numbers is rather simple 123° 22' 30'' is read as One hundred twenty-three degrees, twenty-two minutes and thirty seconds. This is a West bearing that runs through Southern Oregon. Everything in North America is read as a North or West bearing. That is because we are North of the Equator and West of the Prime Meridian.

> **Symbols**
> ° = Degree
> ' = Minute
> " = Seconds

It took me a little while to become used to this next part. Here in North America the following is true.

(1) The <u>horizontal lines that run East and West on your map</u> and around the globe are the <u>North bearing</u>. These horizontal lines encircling the globe grow larger in degree as you go North of the Equator

(2) The <u>vertical lines that run North and South on your map</u> and around the globe are the <u>West bearing.</u> These vertical lines grow larger in degree as you go West of the Prime Meridian.

For North America

North bearing lines run horizontally (from side to side) and you read them from the bottom of the map going up. This is the distance North of the Equator. = Latitude

West bearing lines run up and down vertically and you read them from right to left. This is the distance West of the Prime Meridian = Longitude

Your map may have the degrees, minutes and seconds along the edge of your map and may not have the connecting grid lines drawn across the map. You may only have tick marks on the edge. In this case you can take a straight edge and carefully connect the tick marks from each side of the map. (I use my 4-foot level for this process.) You will also notice that there are cross sections across the map that line up with these opposing tick marks. They just look like a + on the map.

123° 22' 30"

42°
30'
00"

← **Tick-mark**
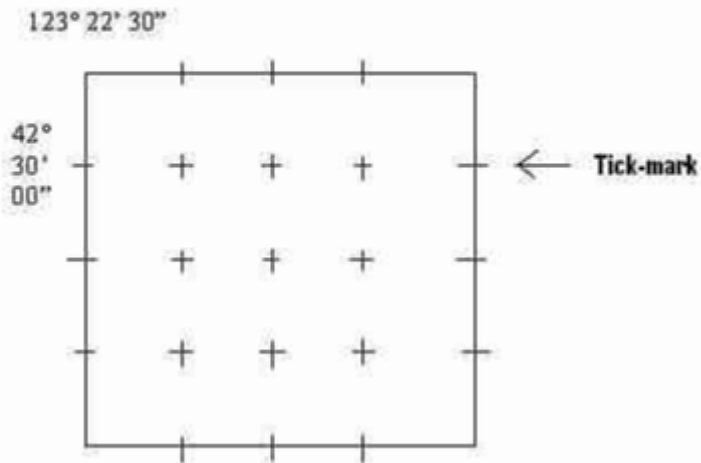
(Illustration 1)

Anywhere that these Latitude and Longitude lines cross can be entered as a "Waypoint" into your G.P.S receiver. Then you can use your Navigate or GOTO mode, etc. (depending upon your receiver) to travel to that point. For example: You could enter the horizontal line 42° 22' 30 for a North bearing and the vertical line 123° 15' 00" for a West bearing into your G.P.S receiver and navigate to it. (See map on last page) Upon arrival you would be close to Grant Pass Peak in Southern Oregon. What if you wanted to go to Dollar Mountain? There are no grid lines that cross Dollar Mountain. To determine the G.P.S coordinate for that location will require two measurements on the map and a little bit of math.

CHAPTER 2
Why do I need a math formula
to find a specific location?

One can enter the coordinate where two grid lines cross by using the degrees for each line and entering it into the G.P.S as a Waypoint. However most likely any location that you wish to travel to will not be where the grid lines on your map cross. The grid lines are measured as degrees, minutes and seconds. Therefore one must determine how many minutes and seconds the desired location is from the known grid line. This conversion of distance on the map to minutes and seconds is a simple math problem. The good news is you only have to figure out the seconds per part on your ruler one time for each different map scale that you normally use in your area as will be explained shortly.

What we are going to figure out is how much distance does one millimeter on your ruler represent? Once that is figured out we will then make two measurements from existing grid lines on the map.

Then add the measured distance with the ruler to the Latitude and Longitude lines on the map that you measured from.

Every location on the North America continent has a coordinate where Latitude and Longitude cross and we will be able to determine that coordinate from the map without the G.P.S and without going there first.

CHAPTER 3
How do I develop this math formula for the maps I use?

First I would like to share how easy it is going to be before you become scared by thinking, but I hate math! First of all you get to use a calculator. It will take about a half hour to determine how many seconds are in each segment of your ruler. This you will only have to do once and then you will never have to do it for that map again. Once that is determined it will only take a couple of minutes to figure out what the G.P.S coordinate is for anything on that map.

This process and the following chapters will probably be easier if you actually follow the stepswith both the map and measurements using the map at the back as we locate Dollar Mountain. I really draw out the explanations, but once you grasp what we are doing you will be surprised at how easy it really is.

(3a) First you will select your favorite map that has the degrees of latitude and longitude marked along the edges.

(3b) Look to see if the grid lines connect the degrees of latitude and longitude across the map. The grid lines will need to be drawn in with a straight edge, if they are not there already. In the event the grid lines are not drawn in then connect the opposing tick marks by each line of latitude and longitude. Make sure that you also connect the cross sections that look like a + when you do this as was previously seen in illustration 1. Use extreme care when doing this. A line that is off will also make your coordinate off when you are in the field.

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(3c) Figure out how many minutes and seconds that is between each degree mark. To do this simply take two numbers from across the top of the map that are next in line to each other. Then subtract the number on the right from the number on the left.

For example on my map (See last page or illustration 2) I took 123° 22' 30" - 123° 15' 00" = 7'30".

That is 123°degrees, 22' minutes, 30" seconds minus 123° degrees, 15' minutes and 00" seconds = 7' minutes and 30" seconds. Now write down how many minutes and seconds between vertical grid lines that you found on your map.

$$\begin{array}{r} 22'30" \\ -\ 15'00" \\ \hline 7'30" \end{array}$$

(Illustration 2)

SIDE NOTE: In case your map does not show the degrees, minutes and seconds on every grid line. Then you will have to determine the bearing for the un-named grid lines yourself.

Unlike the map at the back some maps may only show the degree on every other grid line and place a tick mark in the middle between the two grid lines that are marked. For example my Idaho Panhandle National Forest map does not draw in the grid lines and skips the labeling of every other tick mark. I drew in the grid lines by using my 4-foot level as a straight edge and connecting the tick marks. On the top of the map the first grid line is marked 117° degrees. The next grid line to the right was not marked. The next grid line to the right of that is marked 45'. The next grid line to the right of that was unmarked. The next grid line to the right of that is marked 116° 30'. (See Illustration 3)
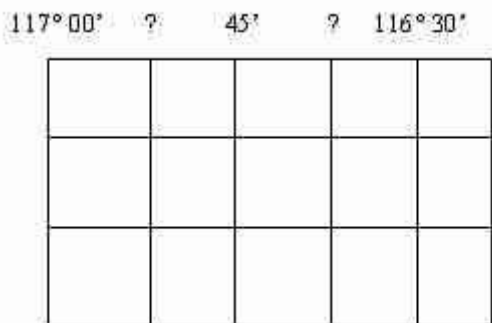
(Illustration 3)

(Notice my Idaho Panhandle National Forest map does not always place the degree. It also does not always place the seconds when it ends in an even minute.)

So I was looking at (117° 00', ?, 45', ?, 116° 30') it was up to me to fill in the blanks. I knew that since the degrees grow larger reading from right to left I should be starting from the right 116° 30' moving left to the 45.' (45 - 30 = 15) That means that between the grid line with the 30' minutes I would move left past the unnamed grid

line to the grid line labeled 45' minutes. Between these two points was a span of 15 minutes. Therefore the unlabeled grid line in the middle of 45 minutes and 30 minutes is exactly half of the 15-minute span between the two labeled grid lines. Divide 15 in half and we get 7.5. That is 7 minutes and half of a minute or 7 minutes 30 seconds. I add the 7 minutes 30 seconds to the 116° 30'. The unlabeled grid line between116° 30' and 45' is 116° 37' 30" (Written as hundredths of a minute it would read 116° 37.50) To label the grid line between the 45 minutes and 117° degrees we now know to add 7' minutes, 30" seconds to the 45' minutes.

(45' + 7' 30" = 52' 30") or (45 minutes + 7 minutes, 30 seconds = 52 minutes, 30 seconds) So the next unlabeled grid line is (116° 52' 30") We now can add 7 minutes 30 seconds to this and we will have the next labeled grid line of 117° degrees.

(Remember there is only 60 minutes in 1 degree)
Before I filled in the blanks I had
(117° 00', **?,** 45', **?,** 116° 30') as seen in illustration 3.
After filling in the unnamed grid lines I had:
(117° 00', 116° 52'30", 116° 45', 116°,37'30"
,116° 30') the complete form reads:
(117° 00' 00"**,** 116° 52' 30"**,** 116° 45' 00"**,** 116° 37'30"**,**
116° 30' 00")
Written with hundredths of a minute instead of seconds it would read:
(117° 00**.**00**,** 116° 52**.**50**,** 116° 45**.**00**,** 116° 37.50,
116° 30**.**00)   **END OF SIDE NOTE**

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Now that you have figured out how many minutes and seconds there are between each degree mark we will convert them all to seconds

(3d) Use a calculator to convert all of the minutes and seconds to seconds. I had 7 minutes and 30 seconds between grid lines. In my case I did the following. There are 60 seconds in a minute. So 7 minutes X 60 seconds = 420 seconds. Next I added the remainder of the 30 seconds. (420 seconds + 30 seconds = 450 seconds.) So there are 450" seconds in 7' minute's 30" seconds.

(3e) Next take a ruler and measure between any two vertical lines next to each other at the top and bottom of the map. It can be a standard ruler or a metric ruler. You will get greater accuracy for your G.P.S coordinate by using a ruler that has more lines or parts in it. In this case I used a metric ruler. My map of the Rouge River National Forest map has two sides. On the bottom of the South portion of the map I measured 8.2 cm between the vertical lines. On the other side at the top or North portion of the map I measured 8.0 cm between the vertical lines The 8.2 cm represents 82 segments on a number line. The 8.0 cm represents 80 segments on a number line. I chose to work with 8.1 cm or 81 segments on a number line. I chose this because that number is in the middle giving me the most reliabilityfor the largest portion of the map. (See illustration 4)

(For those who cannot read a metric ruler you may want to jump ahead and read the first part of chapter 10 on
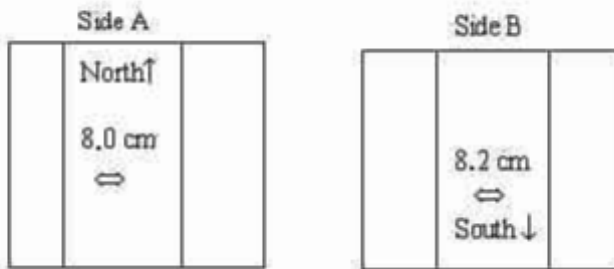
(Illustration 4)

Using 8.1 will produce some degree of error. A greater distance measured on the map will produce a greater error. However the greatest distance I would measure is half of that distance or 41 mm. This would calculate to a maximum error of 3 seconds at the far North or South part of the map. To me that is not a problem, but if you want to increase accuracy you can figure the seconds per mm for different parts of the map. (This map is about 97 miles in-between points of the North and South section. This is a large area that I only use one math formula.)

Remember the reason why these vertical lines vary in distance is because they are more compressed as one travels North or South of the Equator. This is because the world is round in shape.

(3f) Next use a calculator to divide the number of seconds that you found by the number of segments that you measured. In my case I had 450 seconds divided by 81 segments on the ruler = 5.5555555. I rounded this off to the 4th digit past the decimal point and got 5.5556. (Remember we used the vertical lines here.) In other words on my map each measured mm segment represents about 5.5556 seconds for the West bearing for my G.P.S receiver.

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(3g) You just figured out how many seconds are in each segment of your ruler for the West bearing. **Now you will have to <u>do the same thing for the North bearing</u>**. I had 7 minutes 30 seconds between lines on the top of the map. I also have 7 minutes 30 seconds between lines on the side of the map. However many minutes and seconds you found between lines on the top of the map should be consistent with how many minutes and seconds you have on the side of the map. The minutes and seconds will be the same, but the distance will not be the same. So next <u>measure the distance between two horizontal lines on the side of the map.</u>

On my map there were 10.9 cm between the horizontal lines. That means there is 109 mm or segments on a number line between the two horizontal lines. Unlike the vertical grid lines the distances between the horizontal gird line is consistent throughout the map.

(3h) Next <u>divide the number of seconds that you found by the number of segments that you measured.</u> In my case the 7 minutes and 30 seconds equaled 450 seconds and I had 109 segments between the horizontal lines. So I divide 450 seconds by 109 segments that equals 4.1284403. I rounded this off to the 4th digit past the decimal point and got 4.1284. In other words on my map each measured mm segment represents 4.1284 seconds for the North bearing for my G.P.S receiver.

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Conclusion: I used a US Forest map that has a scale of 1:126,720 in Southern Oregon. The map scale is found in the legend on your map. (Map scales are explained more in chapter 7) My map has 7 minutes 30 seconds between grid lines. I used a metric ruler and found that I had an average of 8.1 cm between the vertical grid lines. I also had 10.9 cm between the horizontal grid lines. I did the math and found that whenever I measure a distance on this map each mm on my ruler represents the following.
North Bearing = 4.1284 seconds **per mm.**
West Bearing = 5.5556 seconds per mm.

This process will need to be done for each map scale that you use in the same area.

Now that you know how to do this part you can use the following checklist to help you prepare the math formula for all of your favorite maps. You can write the seconds per mm for the North and West bearing on your map. This way you will not forget it.

(3a) First you will select your favorite map that has the degrees of latitude and longitude marked along the edges.

(3b) Look to see if the grid lines connect the degrees of latitude and longitude across the map. If the grid lines are not drawn in then you will have to draw them in with a straight edge.

(3c) Figure out how many minutes and seconds that is between each degree mark.

(3d) Use a calculator to convert all of the minutes and seconds to seconds.

(3e) Take a ruler and <u>measure between the two vertical lines at the top and bottom of the map.</u> Next take an average between the two measurements.

(3f) Next divide the number of seconds that you found by the number of segments that you measured and round it off to the 4th digit past the decimal point.
Write down the number. (West Bearing)

(3g) Next measure the distance <u>between two horizontal lines on the side of the map</u>.

(3h) Now divide the number of seconds that you found by the number of segments that you measured and round it off to the 4th digit past the decimal point.
Write down the number. (North Bearing)

CHAPTER 4
How do I use addition to find a G.P.S coordinate for anything on my map without going there first?

To find a G.P.S coordinate from your map you will require four steps. These steps will involve measuring from two different grid lines, converting the measured distance from the map to minutes and hundredths of a minute. Then you will have to either add or subtract the sum of those minutes and seconds from the degree marked on the map. That is all there is to it and it will only take a couple of minutes.

Here again this is going to be easier than it sounds. I am going to really draw out the explanation to make it clear as I can. However in reality once you understand how it works there is not much to it.

This will not be an exact science. In other words this will get you there so you can find your desired location, but it is not always going to bring you within 100 feet of that location. I will explain why after I explain the process of addition and subtraction. Later in the book are tips to find things even with a coordinate that is not exact. Following is a break down of the four steps needed to find your desired location. In the process of this breakdown we will use Dollar Mountain as an example, which is found on the map at the back.

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(4a) To find any specific location on the map <u>using addition</u> take your ruler and measure the distance from the nearest vertical grid line East (or to the right) of the desired location. Remember the degrees grow larger in number going West of the Prime Meridian. By measuring from a grid line to the right of the desired location we will have to add the necessary amount of minutes and seconds. The degrees grow larger going from the right of the map to the left. Write the measured distance down for the West bearing.

(4b) The next thing you will do is measure the distance from the nearest horizontal grid line South of (or below) the desired location. By measuring from a grid line below the desired location we will have to add the necessary amount of minutes and seconds. The degrees grow larger going from the bottom of the map up to the top. Write your measured distance down for the North bearing.

Example on my map (See last page.)
Dollar Mountain is approximately 6.6 cm West of bearing 123° 15'00" (4a).
Dollar Mountain is also approximately 7 cm North of the bearing 42° 22'30" (4b).

From here on we will be using hundredths of a minute instead of regular seconds.
Your G.P.S receiver **in the "initialize"** or **Setup** process will give you a choice of Deg/Min/Sec or Deg/ Min/ MMM or Deg/ Min/MM. **We will be working with Deg/ Min/ MM.** So you will want to set your receiver on this mode before entering a Waypoint. You can verify that you have it set correctly by entering a Waypoint. There should be two digits after the minutes and you should be able to change both digits to nine to make it read 99. Deg/Min/Sec can only go to 59 before changing

the minutes. Also when set on <u>Deg/ Min/ MM there will be a decimal point with 2 digits to the right</u>.

In contrast the Deg/Min/Sec will not have a decimal point and the Deg/ Min/ MMM will have 3 digits to the right of the decimal point instead of 2. We want a decimal point with only 2 digits to the right of it.

Note: Also <u>in the **"initialize,"** or "**Setup"** process</u> you will find that you can change your North Reference. I travel using my hand held compass. Therefore I also set my G.P.S on Magnetic North instead of True North. For simplicity I do not set the declination on my compass because I follow a Magnetic North bearing to the Waypoint.

Now back to our hundredths of a minute. The reason we are using MM is because the calculator that we are working with will go up the number 9 in every digit. A measurement in regular seconds will turn over after reaching the number 59. In other words we will divide by 60 to determine minutes. The last two digits in the remainder of our calculation will be in measurements of hundredths of a minute. The process to get seconds instead of hundredths of a minute is slightly different. For simplicity we will use hundredths of a minute. In the event you cannot change your G.P.S to read hundredths of a minute you can still use Degrees, Minutes and Seconds. A brief explanation of the difference and how it works will be given at the end of chapter 5.

(4c) Now we will convert the measured distance on the map to minutes and hundredths of a minute. We will do the North bearing first.

Dollar Mountain is approximately 7 cm North of the bearing 42 22'30".

There are 70 mm in 7 cm. In other words there are 70 segments represented on the number line.

Remember, when I previously did the math for my map (chapter 3, h) 4.1284 is the number of seconds per mm for the North bearing. So I multiply 70 mm by 4.1284 seconds per mm = 288.988 seconds. There are 288.988 seconds in 7 cm.

We divide the 288.988 seconds by 60 to determine the amount of minutes. We divide by 60 because there are 60 seconds in a minute.
(288.988 divided by 60 = 4.8164666) Now we will round this number off to the nearest hundredth after the decimal point. We now have 4.82. That is the 70 mm to Dollar Mountain is equal to 4 minutes and 82 hundredths of a minute. This will be added to the grid line we measured from 42° 22'30".

The 30" here taken from the map is still regular seconds, so first we will change this to read as hundredths of a minute. Thirty seconds is one half of a minute. One half of a minute written as a decimal is .50 So I write down 42° 22'.50 + 4'.82 = North bearing.
I will save this for the 4th and final step.

Now, we will figure out what the West bearing is. Dollar Mountain is also approximately 6.6 cm West of bearing 123° 15'00". The 6.6 cm has 66 mm in it. That is there are 66 parts represented on the number line. Remember when I previously did the math for my map (Chapter 3, f) 5.5556 is the number of seconds per mm for the West bearing.

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T　　　　　I multiply 66 mm by 5.5556 seconds that equals

366.6696. There are 366.6696 seconds in the 66 mm on my map from the grid line 123 15'.00 to Dollar mountain. Next I divide 366.6696 seconds by 60 to find out how many minutes I will have to add. So 366.6696 divided by 60 = 6.11116. I round this off to the nearest hundredth and I have 6'.11. That is I have 6 minutes and 11 hundredths of a minute to add to the West Bearing line that I measured from. I write down the 6'.11 West and proceed to the 4th and final step.

　　　　Important Side Note: Suppose your measured mm from the West grid line on the map was actually 6 mm. When you multiplied the 5.5556 seconds by 6mm your answer would be 33.336 seconds, which is less than a minute. This would represent actual seconds so we would still divide that by 60 to convert it to hundredths of a minute. 33.336 divided by 60 = .5556 .We would then round this off to .56 and add it to the grid line we measured from. Remember when adding this to the grid line from the map that you need 100 hundredths to equal one minute. **(See also Important side note on page 29)**

(4d) The 4th and final step is to add the minutes and hundredths of a minute to the grid lines that we measured from. We will do the North bearing first.

　　　　We measured from the grid line of 42 degrees, 22 minutes, 30 seconds. We also changed the 30 seconds to read as hundredths of a minute and came up with 42° 22'.50 We wrote down that we had to add 4 minutes and 82 hundredths of a minute to the North bearing we measured from. So we have 42° 22'.50 + 4'.82 = ?

　　　　Using your calculator you do not input the 42 degrees. We are only adding the minutes and hundredths of a minute.

　　　So, use your calculator to add 22.50 + 4.82 = 27.32 The number 27.32 is your minutes and hundredths of a minute. Now place the 42 degrees back in front of it.

The North bearing for Dollar Mountain is 42° 27'.32 Now we will add the minutes and hundredths of a minute to the West bearing. We measured from the grid line of 123° degrees, 15' minutes and 00" seconds. (The 00" seconds did not have to be converted to hundredths of a minute since zero is always zero on any number scale.) We also wrote down that we had to add 6 minutes and 11 hundredths of a minute to the West bearing line we measured from.

So we have 123° 15'.00 + 6.11 = ?

Again using your calculator you do not input the 123 degrees. We only use the calculator to add 15.00 + 6.11 = 21.11 We place the 123 degrees back in front and we have a West bearing of 123° 21.11

Dollar Mountain is located at:
42° 27'. 32 N
123° 21.11 W
Elevation 1862 (The elevation we have seen on the map)

Here is your checklist for chapter 4
(4a) Measure the distance from the nearest vertical grid line East (or to the right) of the desired location.

(4b) Measure the distance from the nearest horizontal grid line South of (or below) the desired location.

(4c) Convert the measured distance on the map to minutes and hundredths of a minute. (Make sure your G.P.S is set to read hundredths of a minute)

(4d) Add the minutes and hundredths of a minute to the grid lines that you measured from.

You can now enter this coordinate into your G.P.S receiver as a Waypoint and travel directly to it.

How do I use subtraction to find a G.P.S coordinate for anything on my map without going there first?

Next we will be using subtraction to find Dollar Mountain. One good reason to be able to do both addition and subtraction to find the desired G.P.S coordinate is to double-check yourself. By using both addition and subtraction and getting the same coordinate you can be confident that you did the measuring and math correctly. We have rounded off some numbers. For this reason the coordinate for addition and subtraction may not be an exact match. However when there is only a discrepancy of .01 in the coordinate you can still be sure that you did your math and measuring correctly. When double-checking yourself add the cm's that were measured to the Waypoint for both addition and subtraction. Make sure these two measurements equal the actual distance between the grid lines for that location on the map. Example the vertical lines on my map change between the far North and South end. There are 8.0 cm on the North end and 8.2 cm on the South end of the map. Dollar Mountain is located where there are actually 8.1 cm between the vertical grid lines of 123° 22'30 & 123° 15' 00". For addition I had measured a distance of 6.6 cm from the grid line 123° 15' 00". As you will soon see for subtraction I measured a distance of 1.5 cm from grid line 123° 22'30" So to make sure that I measured correctly I added the two measured distances together. In this case 1.5 cm + 6.6 cm = 8.1 cm. That is the actual distance between the two vertical grid lines near Dollar Mountain. This verifies that I measured correctly for the West bearing.

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　　　　　　I can also double-check my math by adding the

seconds I had for both addition and subtraction together.
As you will see later I found with subtraction the West
bearing has 83.334 seconds in 15 mm on my map from
the grid line 123° 22'30" to Dollar Mountain. For
addition I found there were 366.6696 seconds in the
66 mm on my map from the grid line 123° 15'.00 to
Dollar Mountain. 83.334 + 366.6696 = 450.0036 or
rounded of to the nearest hundredth.
83.33 + 366.67 = 450. Remember there is 450 seconds
between the grid lines on the map with Dollar Mountain.
Using the seconds for both addition and subtraction add
up to the 450 seconds between the grid lines verifying
that the math to that point is correct for the West bearing.
　　　　　The math and measurement for the North bearing
can be double checked in the same manner.

(5a) To find any specific location on the map using
subtraction take your ruler and measure the distance
from the nearest vertical grid line West (or to the left)
of   the desired location. Write the measured distance
down for the West bearing.

(5b) Next we will measure the distance from the
nearest horizontal grid line North of (or above) the
desired location. Write that measured distance down for
the North bearing.

Example on my map (See last page.)
Dollar Mountain is approximately 1.5 cm East of bearing
123° 22'30" (5a).
Dollar Mountain is also approximately 3.9 cm South of
the bearing 42° 30'00" (5b).

(5c) Now we will convert the measured distance on the map to minutes and hundredths of a minute.

We will do the North bearing first.

Dollar Mountain is approximately 3.9 cm South of the bearing 42° 30'00". There are 39 mm in 3.9 cm. In other words there are 39 segments represented on the number line.

Remember when I did the math for my map (chapter 3, h) 4.1284 is the number of seconds per mm for the North bearing. I multiply 39 mm by 4.1284 seconds per mm = 161.0076 seconds. There are 161.0076 seconds in 3.9 cm.

The 161.0076 seconds is then divided by 60 to determine the amount of minutes. We divide by 60 because there are 60 seconds in a minute.

(161.0076 divided by 60 = 2.68346) Now round this number off to the nearest hundredth after the decimal point. We now have 2.68. The 39 mm from Dollar Mountain is equal to 2 minutes and 68 hundredths of a minute. This will be subtracted from the grid line we measured from 42° 30'00".

So I write down 42° 30'.00 - 2'.68 = North bearing. I will save this for the 4th and final step.

Now we will figure out what the West bearing is. Dollar Mountain is also approximately 1.5 cm East of bearing 123° 22'30". The 1.5 cm has 15 mm in it. There are 15 parts represented on the number line. Remember when I did the math for my map (Ch 3f) 5.5556 is the number of seconds per mm for the West bearing.

I multiply 15 mm by 5.5556 seconds that equals 83.334. There are 83.334 seconds in the 15 mm on my map from the grid line 123° 22'30" to Dollar Mountain. Next I divide 83.334 seconds by 60 to find out how many minutes I will have to subtract. So 83.334 divided by 60 = 1.3889. Next I round this off to the nearest hundredth and I have 1'.39. I have 1 minute and 39 hundredths of a minute to subtract from the West Bearing line 123° 22' 30" that I measured from.

The 30" here in the West bearing is still regular seconds so first we will change this to read as hundredths of a minute. Thirty seconds is one half of a minute. In the decimal format one half a minute is written as .50 So I write down 123° 22'.50 - 1'.39 = West bearing and proceed to the 4th step.

Important side note. Do not forget that if you had less than 60 seconds after multiplying the parts per mm that you still must divide that by 60 to convert it to hundredths of a minute. This is true for both North and West Bearings whether adding or subtracting.
(See also Important side note on page 24)

(5d) The 4th and final step is to subtract the minutes and hundredths of a minute from the grid lines that we measured from. We will do the North bearing first.

We already measured from the grid line of 42 degrees, 30 minutes, 00 seconds.
We wrote down 42° 30'.00 - 2'.68 = North bearing.

Here again we do not enter the degree into the calculator. We are only subtracting the minutes and seconds.

So in the calculator we input 30.00 - 2.68 = 27.32 The number 27.32 is our minutes and hundredths of a minute. We place the 42 degrees back in front of it and we have 42° 27'.32 for the North bearing of Dollar Mountain.

Next we subtract the minutes and hundredths of a minute for the West bearing.

We wrote down 123° 22'.50 - 1'.39 = West bearing.
We do not enter the 123 degrees into the calculator.
We input into the calculator 22.50 - 1.39 = 21.11
The number 21.11 is our minutes and hundredths of a minute. We place the 123 degrees back in front of it and we have 123° 21'.11 for a West bearing.

Dollar Mountain is located at:
        42° 27'.32 North
        123° 21'.11 West
        Elevation 1862
(The elevation we have seen on the map)

Note: Keep in mind the calculator will not show a 0 in the second digit after the decimal point when not needed. Example .20 would simply appear as .2 they are in fact the same amount. However, you need two digits to enter into the G.P.S receiver. So you would simply ad "0" to .2 to have .20
        Also you may at times have to subtract from an even degree. Lets say that you needed to subtract 4.23 or 4 minutes and 23 hundredths of a minute from 117 degrees. That means you have to first borrow one degree from the 117 degrees. Then we would have 116 degrees and 60 minutes. You still cannot subtract 23 hundredths of a minute until you borrow one minute from the 60 minutes. One minute written in the hundredth's form is 100. We would have the following: 116 degrees 59 minutes & 100 hundredths of a minute minus 4 minutes and 23 hundredths of a minute. We would do each category separately starting with the hundredths of a minute. (100 hundredths of a minute - 23 hundredths of a minute = 77 hundredths of a minute)

Then we would subtract the minutes.
(59 minutes - 4 minutes = 55 minutes)
So we have 117 degrees minus 4 minutes & 23 hundredths of a minute = 116 degrees, 55 minutes and 77 hundredths of a minute.
(117 degrees - 4.23 = 116° 55.77)

In regular use, I always measure from the nearest vertical grid line to my desired location. I also measure from the nearest horizontal grid line. This will help to cut down the severity of errors in math or measurement. A minor error in math or measurement becomes a greater error over distance. The reason why is because we are multiplying the seconds per mm by the measured number of segments. The errors in math or measurement are multiplied as well in the process. The errors become increased with a longer measured distance. I have found in practice that I do better even when I measure wrong etc., if I always measure from whichever grid line is closest to my desired Waypoint.

This means that I may add to the North bearing and Subtract from the West bearing or vice versa. It can also mean that I use subtraction for both the North and West bearing or addition for both. It just depends upon where my desired location is in relation to the nearest grid lines. Remember the following:

North bearing
For addition you will be measuring (up or North) of the nearest horizontal grid to the Waypoint.
For subtraction you will be measuring (down or South) of the nearest horizontal grid line to the Waypoint.

West bearing
For addition you will be measuring (left or West) of the nearest vertical grid line to the Waypoint.
For subtraction you will be measuring (right or East) of the nearest vertical grid line to the Waypoint.
(See Illustration 5 on next page)

You can look at the map to see which direction the degrees grow larger for a reminder.

When you are measuring in the same direction as the degrees grow larger you will be adding the minutes and seconds. (North or West, up or left)

When you are measuring in the same direction as the degrees grow smaller you will be subtracting the minutes and seconds. (South or East, down or right)

(Illustration 5)
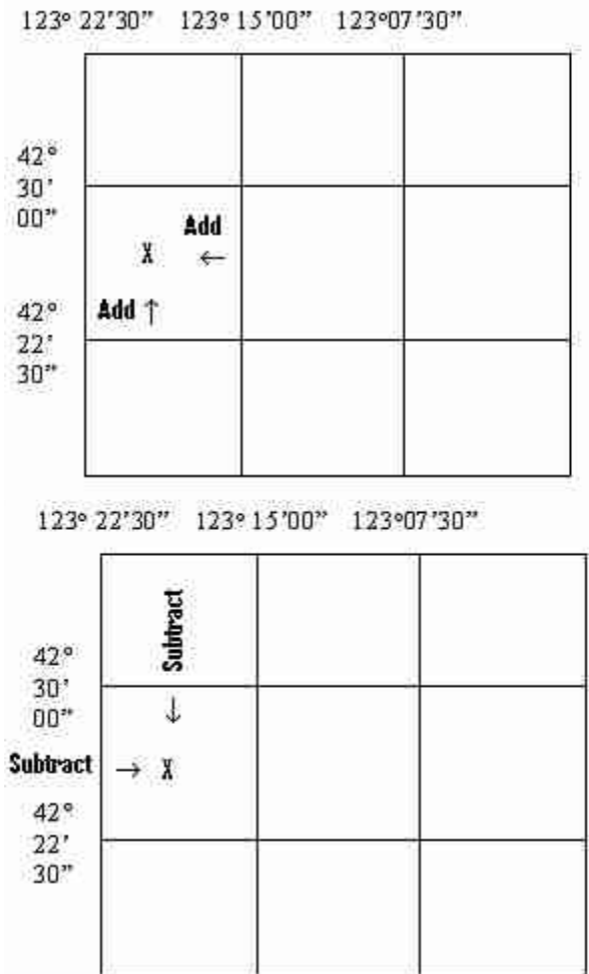
Here is your checklist for chapter 5

(5a) Measure the distance from the nearest vertical grid line West (or to the left) of the desired location. Write the measured distance down for the West bearing.

(5b) Measure the distance down from the nearest horizontal grid line North of (or above) the desired location.

(5c) Convert the measured distance on the map to minutes and hundredths of a minute. (Your G.P.S needs to be set to read hundredths of a minute.)

(5d) Subtract the minutes and hundredths of a minute from the grid lines that you measured from.

You can now enter this coordinate into your G.P.S receiver as a Waypoint and travel directly to it.

REASONS FOR A SMALL DEGREE OF ERROR.
1. The distance between the vertical degree lines may not be consistent. Therefore your seconds per mm calculation may not be exact for the entire map.
2. Rounding any number off means that it is close, but it is no longer exact. This applies in the seconds per mm calculation that you use. It also applies when you round off to the nearest hundredth of a minute.
3. Your ruler needs to be completely vertical or horizontal when you measure or there will be some degree of error. The error would exist because the angle can change the actual distance.
4. When you measure the actual location may fall between the lines on your ruler. This is similar to rounding off a number.

5. The grid lines may not be exact, if you had to draw them in yourself by connecting the opposing tick marks
6. Your measurement to your desired location can also be off slightly when you are working on a less than flat surface like the ground.
7. Small map scales may have greater room for error than larger map scales (Chapter 7)
8. The US Government imposes some small amount of error through the satellites for civilian use.
9. All map makers must include small distortion errors into the map because they are representing a spherical shape of the world on a flat piece of paper.

The good news is these are all small degrees of error. Small amounts of error will not keep you from finding your desired location. It just means do not expect to navigate to within 10 feet of your location every time you go out. That simply is not going to happen. However you can expect to find your location every time. Lets say that you are looking for a lake. You do your calculations and travel there. Lets say for some unknown reason you were 500 feet off in your calculations. It does not matter at only 500 feet away you can probably see the lake.

In the event that you get an incorrect coordinate in your practice runs you can double-check the following things.
1. Did you measure correctly the distance between the vertical and horizontal lines when you developed your seconds per part on the ruler that you multiply by?

2. Did you determine the correct amount of seconds between each grid line when you developed your seconds per part on the ruler that you multiply by?

3. Do you come up with the same coordinate using both addition and subtraction for both the North and West bearing?

4. Do your measured distance using addition and your measured distance using subtraction add up to the actual distance between the vertical and the horizontal lines for that location on the map?

5. Do the number of seconds that you come up with for both addition and subtraction together equal the actual number of seconds that are in-between grid lines?

6. Is your G.P.S receiver set on Degrees, Minutes and hundredths of a minute?

7. Is your G.P.S receiver set on Magnetic North?
(Read "A word about declination")

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To make this process easier in the field I used to carry copies of something like this with me.
USFS map scale 1:26,720
(7 min. 30 sec. between degree lines)

NORTH BEARING = Horizontal lines connecting the right and left side of the map.
Find where you want to go on the map.
Remember for addition you will be measuring
(Up or North) of the nearest degree lines.
For subtraction you will be measuring (down or South) of the nearest degree line.

(1) Write down the degree from the map. Circle the + or - in step (1) Don't forget if the map's coordinate ends in 30" change that to the decimal .50

 Deg.   Min.   100ths   Min.
100ths

___ ___ ___ ___ **.** ___ ___ + or -   ___ ___ **.** ___ ___
= North bearing (Elev. _____)

(2) Measure CM to the nearest horizontal grid line. Write the number of parts. _____

(3) Multiply this number by 4.1284 _____

(4) **If the number is above or below 60 divide by 60.** Then round off the remainder to the nearest hundredth and write down the minutes and hundredths that need to be added to or subtracted from the North bearing in step (1).

WEST BEARING = Vertical lines connecting the top and bottom of the map.

Remember for addition you will be measuring (left or West) of the nearest degree lines.

For subtraction you will be measuring (right or East) of the nearest degree line.

(1) Write down the degree from the map. Circle the + or - in step (1) Don't forget if the map's coordinate ends in 30" change that to the decimal .50

Deg.   Min.   100ths   Min. 100ths

___ ___ ___ ___ . ___ ___ + or -   ___ ___ . ___ ___
= West bearing

(2) Measure CM to the nearest vertical degree line. Write the number of parts. _____

(3) Multiply this number by 5.5556 _____

(4) **If the number is above or below 60 divide by 60.** Then round the remainder off to the nearest hundredth and write down the minutes and hundredths that need to be added to or subtracted from the West bearing in step

(1).

Add or Subtract the information for North and West bearings and fill out the blanks below, as it will be in the GPS.

WPT _____

___ ___ ___ ___ . ___ ___ North bearing
___ ___ ___ ___ ___ . ___ ___ West bearing
Elevation _____ From the map.

BE SMART PRACTICE FIRST!

You are likely to make some mistakes as you become familiar with figuring out how to determine the coordinate to a location on your map. So do not make your first attempt to locate something a cross-country trip into unfamiliar territory. Pick a location on your map that you already know where it is. While you are still at home determine the G.P.S coordinate for that location. Now head out pretending that you really do not know where it is and let your G.P.S, map and compass lead you there. Do this several times picking several locations that you already know how to find. Use both addition and subtraction to find the same coordinate. By doing this in familiar territory first you will become accustomed to what to expect. You will also know what mistakes you are most likely to make. Therefore you will also be able to know how to correct your most common mistakes. While you are at your known Waypoint you can also practice locating yourself on the map, as you will learn how to do in chapter 8.

Using Degrees, Minutes and Seconds (Deg/Min/Sec) instead of Degrees, Minutes and hundredths of a minute (Deg/ Min/MM)

Using the hundredths of a minute instead of seconds as the last part of the coordinate is really just a matter of preference. It saves me steps with the calculator so I chose to work with hundredths rather than seconds. For the most part the process is identical. Locating Dollar Mountain I had 288.98 seconds to add to the North bearing. (See 4c) There I simply divided that number by 60 to get the minutes and hundredths of a minute. To have minutes and seconds one must first subtract the largest multiple of 60 and the remainder will be seconds. I Multiply 60 in my head so I don't erase the 288.98 in the calculator or have to write it down.

I know that 60 X 4 = 240. Therefore I take the 288.98 and subtract 240 in the calculator. The 4 that I multiplied by is the number of minutes. The remainder after subtracting 240 is the number of seconds. 288.98 – 240 = 48.98 So I have 4 minutes and 48.98 seconds to add to the North bearing. I will round this off and add 4 minutes 49 seconds to the North bearing. So instead of the 42 27'.32 that I had in (4d) I add 4 minutes 49 seconds to 42 22' 30". The seconds here will be added separately before the minutes. 49 seconds + 30 seconds = 79 seconds which is equal to 1 minute and 19 seconds including the previous 4 minutes that is 5 minutes 19 seconds added to the North Bearing.

That gives us **42 27' 19" for the North bearing.**
(Note if you tried to simply divide the 288.98 by 60 you would not get the proper number of seconds.) Using this same process for the West bearing as in (4c) & (4d) I would take the 366.6696 seconds that I had to add to the West bearing and first subtract 360 which is a multiple of 60 to get the 6 minutes and the remainder is seconds instead of hundredths of a minute. 366.6696 – 360 = 6.6696 seconds or 6 minutes and the rounded remainder of 7 seconds to add to the West bearing of
123   15' 00" . (123 15' 00"+ 6 '7"= **123 21' 07" West**)
        Using seconds instead of hundredths of a minute
the coordinate for Dollar Mountain would be
42 27' 19" North
123 21' 07" West
By entering the coordinate for Dollar Mountain and then changing the G.P.S back and forth from degrees, minutes and seconds to degrees, minutes and hundredths of a minute you can see that (42 27' 19" North, 123 21' 07" West) & (42° 27.32 North, 123° 21.11 West) are in fact the same location.

CHAPTER 6
A word about declination.

Webster's Collegiate Dictionary 10th edition says that declination is *"the angle formed between a magnetic needle and the geographical meridian."*

To you that means that declination is the difference between True North and Magnetic North. The declination or the difference between True North and Magnetic North varies depending upon where you are.

The earth's magnetic pull that your compass needle points to is either East of True North or West of True North. Here in the U.S.A Magnetic North and True North are only the same along a line that runs to the West of Florida and up through Lake Michigan. Depending upon where you are in the US the difference between True North and Magnetic North can vary from just a couple of degrees up to about thirty degrees.

True North is higher up on the globe than Magnetic North. At first it seemed backwards to me that on the West Coast here in the U.S.A the compass points East of True North. This means I have to add the declination to turn West to True North. On the East Coast here in the U.S.A the compass points West of True North This means I have to subtract the declination to turn East to True North. Viewing a chart that includes the US and the Arctic Circle showing all of the angles as compared to the magnetic needle in the compass helps a person understand. The good news is you only need to know two things and I will explain them both to you.

(a) Does your G.P.S add or subtract from Magnetic North to get True North?

(b) How many degrees does your G.P.S add or subtract from Magnetic North?

Both of these questions will be answered for you in the following process.

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Your G.P.S can tell you the declination.

Your G.P.S can tell you what the declination is where you are.

(6a) First you will want to make sure your G.P.S receiver is set on Magnetic North. My G.P.S places a small "M" next to a bearing pointing toward a Waypoint when the receiver is set on Magnetic North. My G.P.S also places a small "T" next to a bearing pointing toward a Waypoint when the receiver is set on True North. I can change the North Reference by looking under my "initialize" or "setup" menu in my G.P.S.

(6b) Next you will want to enter several Waypoints into your G.P.S receiver. These Waypoints can be taken from your map where two grid lines cross. A Waypoint can also be from your current position on your G.P.S. Of course, if you set the Waypoint from your current position on your G.P.S you will want to walk away about 1/4 mile before entering another one. Which direction you walk does not matter. You will need to walk away about 1/4 mile for your G.P.S to measure an accurate difference in declination between True North and Magnetic North.

(6c) Next check your G.P.S to see what the Magnetic North bearing is to those Waypoints and write down those bearings.

(6d) Now change your G.P.S to read True North. Then check to see what the True North bearing is to those same Waypoints and write down those bearings.

We will be checking to see what the difference is in those bearings using Magnetic North & True North.

In some areas your G.P.S may vary by 1 degree in

this difference between True and Magnetic North That is OK you are just in an area that is close to in-between the two degrees of declination. Check the difference between True North and Magnetic North on several Waypoints and choose the most prominent one.

Your G.P.S will either add to or subtract from Magnetic North.

(6e) Find out if your G.P.S adds or subtracts from the Magnetic North bearing.

The True north bearings will have a larger number for the degree than the Magnetic North bearings if your G.P.S added the declination.

The True North bearings will have a smaller number for the degree than the Magnetic North bearings if your G.P.S subtracted the declination.

(6f) Find out how many degrees were added to or subtracted from the Magnetic North bearings.

For Example while I was in Post Falls Idaho I entered a Waypoint from a map located in Coeur D' Alene Lake. The Magnetic North bearing to that location 24 miles away was 140 degrees. I then changed the North Reference in the G.P.S to read True North. The True north bearing to that same Waypoint was 159 degrees. The True North degree 159 is higher than the Magnetic North degree of 140 so the G.P.S added to the Magnetic North bearing. I can subtract to find out how much the G.P.S added to the Magnetic North bearing.
(159 - 140 = 19) So the G.P.S added 19 degrees to the Magnetic North bearing to give me the True North bearing. (140 + 19 = 159)

By the way these are not two different directions to the same location. The True North bearing of 159 degrees from where I was to my Waypoint in Coeur D

T

Alene lake is correct. The Magnetic North bearing of 140 degrees from where I was to my Waypoint in Coeur D Alene lake was also correct. The two degrees are equal to each other. They are just on different scales. It is like saying that 30 seconds and .50 of a minute are equal or the same amount of time.

There are two things I need to remember when establishing where I am on the map in that area.
(a) The G.P.S **added** to the Magnetic North bearing to give me the True North bearing.
(b) The G.P.S added **19 degrees** to the Magnetic North bearing.
So for where ever you are in the world you need to answer the same two questions.
(a) Did your G.P.S add or subtract from Magnetic North to get True North?
(b) How many degrees did your G.P.S add or subtract from Magnetic North?

In your area you will always want to do what your G.P.S did. You must add to the magnetic North bearing to get a True North bearing, if your G.P.S added to the Magnetic North bearing.

You must subtract from the Magnetic North bearing to get a True North bearing, if your G.P.S subtracted from the Magnetic North bearing.

You must (add to) or (subtract from) the Magnetic North bearing the same amount of degrees that your G.P.S did.

(6g) Write down whether you are to add or subtract and the number of degrees for the declination in your area.

(6h) Do not forget to change your G.P.S back to Magnetic North.

I do not need to set the declination on my compass to travel to a Waypoint. This is why I always leave my G.P.S set to read Magnetic North. The only time that I change it to read True North is to figure out the declination for a particular area.

Confusing True North and Magnetic North can put you way off course real fast. Lets say that you were 15 degrees off in your direction of travel by using a True North bearing from your G.P.S and using that same bearing with your compass that reads Magnetic North. The course of travel would be off by not including the declination on your compass. By the time you walked one mile you would be one-quarter mile off course.

When you take a Waypoint from the map and use your compass to follow a Magnetic North bearing given by your G.P.S to that Waypoint you do not set the declination on your compass.

When you take a Waypoint from the map and use your compass to follow a True North bearing given by your G.P.S to that Waypoint you must set the declination on your compass.

Keep your G.P.S set to read Magnetic North. By doing so you do not need to ever be concerned about declination to travel to any Waypoint taken from your map. However you will be concerned about declination when using your G.P.S to pinpoint your location on the map. When pinpointing your location on the map you are not traveling so you can leave your G.P.S set to read Magnetic North. You will however include the declination in your math when pinpointing your location on the map. I will explain this later.

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Use the following check list to find the declination for your area.
(6a) Make sure your G.P.S receiver is set on Magnetic North.
(6b) Enter several Waypoints into your G.P.S receiver. **(6c)** Check your G.P.S to see what the Magnetic North Bearing is to those Waypoints and write down the bearings.
(6d) Change your G.P.S to read True North. Then check to see what the True North bearing is to those same Waypoints and write down those bearings.
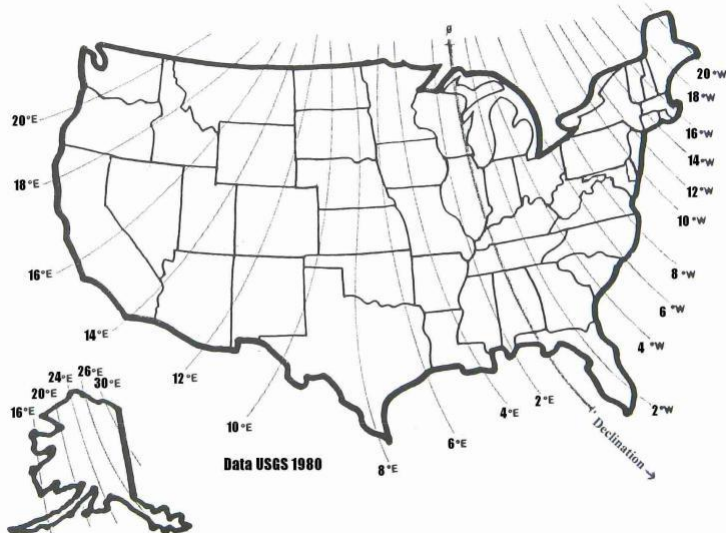**(6e)** Find out if your G.P.S adds or subtracts from the Magnetic North bearing.
(6f) Find out how many degrees were added to or subtracted from the Magnetic North bearing.
(6g) Write down whether you are to add or subtract and the number of degrees for the declination in your area.
(6h) Change your G.P.S back to Magnetic North.

DECLINATION CHART

CHAPTER 7

Why doesn't a single math formula work for all maps?

There are two reasons that the seconds per mm will vary between maps. Remember the seconds per mm are the numbers you multiply your measured distance by to find a coordinate on the map. This was covered in

(a) Your location can change the distance between the vertical lines. As I pointed out earlier my Rouge River National Forest map has 8.2 cm between the vertical lines at the far South end. It was also 8.0 cm between the vertical lines at the far North end. Remember the circles around the globe become more compressed as you go North or South of the Equator. For my map the difference of 2 mm occurred in only 97 miles. Therefore traveling 800 miles off my map would change the cm between the vertical lines even more. At this great of a distance it would change the seconds per mm enough to throw off all of my calculations.

(b) Not all maps are the same scale. Your map has a legend. Here you will find a scale that tells you how far a mile is on your map. You will also have symbols with a short explanation of what each symbol represents. In this same area you will find your map scale. On my Rouge River National Forest map it simply says:
(Scale 1: 126,720) Map scales are like a fraction. The number 1 here would be the numerator. The 126,720 is the bottom part of the fraction or the denominator. Fractions vary in size. Map scales also vary in size.

T   A photo on your drivers' license would be smaller

in proportion than another picture of yourself hanging on the living room wall. It is still a picture of you, but the scale of your driver's license photo is smaller. Map scales are similar. It could be showing detail of the same area, but in larger or smaller proportions.

This means that 7 minutes and 30 seconds on maps of the same area can have a different measured distance between grid lines, if the map scale is different. This of course would mean that the number of seconds per mm of a measured distance would vary with different map scales of the same area.

It is not unusual to come up with a slightly different G.P.S coordinate when figuring the same Waypoint on different maps with different map scales. It will however be close and you will find your desired destination. Generally speaking the larger the map scale the greater your accuracy will be in determining the coordinate. Likewise it is easy to pinpoint the pupil in your eye in a large picture of yourself hanging on the living room wall. It is not so easy to pinpoint the pupil in your eye on your driver's license picture.

For example I used several different maps with different scales to locate Dollar Mountain. On all of the conventional paper maps I used the methods and principles as outlined in this book. I came up with a slightly different coordinate with each one. All of which placed me near the top of Dollar Mountain. Following are examples of the difference.

COORDINATE FROM PAPER MAPS

Delorme Atlas & Gazetter.
(Topo maps in book form.)
Scale 1:150,000
1 inch = 2.4 miles
Dollar Mountain
North 42 27'. 46
West 123 21' .14

Rogue River
National Forest Map
Scale 1:126,720
1 inch = 2 miles
Dollar Mountain
North 42 27'. 32
West 123 21' .11

USGS-Forest Service
7.5 minute series
Scale 1:24,000
2 5/8 inch = 1 mile
Dollar Mountain
North 42 27'.45
West 123 21'.21

USGS National Geographic
Scale 1:34,252
1 9/8 inch = 1 mile
Dollar Mountain
North 42 27'.42
West 123 21'.17

COORDINATE FROM ELECTRONIC MAPS & G.P.S RECEIVER

G.P.S receiver reading
while actually there.
Dollar Mountain
North 42 27'. 42 West
123 21' .27

Delorme Topographical
Maps Electronic version
Dollar Mountain North
42 27'. 413 West 123
21' .313

Map Source by Garmin
Dollar Mountain
North 42 27.410
West 123 21.410

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From the top of Dollar Mountain I used my G.P.S to check to see how far it was to each coordinate that I figured on the paper maps as well as the coordinate given by the Delorme & Garmin electronic maps. The results are as follows:

1. Delorme Topo in book form.
From the top of the mountain to the figured coordinate was 41 .13 miles

2. Rougue River National Forest map.
From the top of the mountain to the figured coordinate was 107 .17 miles

3. National Geographic
From the top of the mountain to the figured coordinate was 32 .09 miles

4. U.S.G.S 7.5 minute series.
From the top of the mountain to the figured coordinate was 25 .08 miles

5. Delorme Topo electronic version.
From the top of the mountain to the figured coordinate was 267 .03 miles

6. Map Source by Garmin electronic version.
From the top of the mountain to the figured coordinate was 256 .12 miles

T As you can see none of the figured locations from the paper or the electronic maps were exact. Saving a Waypoint in your G.P.S and then finding your way back to it will always be more exact than figuring a location that you have never been to before. However ALL of the coordinates figured from paper and electronic maps are close enough to find Dollar Mountain. Chapter 11 gives other tips on finding your location that can make this small error irrelevant.

CHAPTER 8

How does a G.P.S coordinate help me to know where I am on the map?

You can use your G.P.S to tell you where you are on the map. We will be doing the following steps, which will be explained as we go along.

Later you can use this as a checklist when locating yourself on the map.

(8a) Enter a Waypoint where two grid lines cross on the map that you think is near you.

(8b) Check your G.P.S receiver to find the bearing and the distance to that Waypoint.

(8c) Figure out what 180 degrees is from the bearing given by the G.P.S to the Waypoint.

(8d) Take the amount of declination for your area. Add (or subtract) this to the reversed 180-degree bearing given by the G.P.S to the Waypoint.

(8e) Use your protractor with your ruler to find your location on the map.

Each step (a) through (e) will correlate with the checklist above.

(8a) Take two grid lines that cross each other near where you think you might be on the map. Take note of the bearing assigned to each grid line. Take the degree, minute and seconds of the North and West bearing and enter it as a Waypoint into your G.P.S receiver.

(Do not forget to convert any seconds on the map to hundredths of a minute.)

In other words 30" seconds on the map will read .50 for your G.P.S receiver.

(8b) Now check your G.P.S receiver to find the bearing and the distance to that Waypoint.

(8c) Then we will figure out what 180 degrees is from the bearing given by the G.P.S to the Waypoint.

T For example lets say that the G.P.S says that Waypoint is 360 degrees (Due North) and 3.5 miles away. Now if you have to travel 360 degrees due North 3.5 miles to reach that Waypoint then where are you in relation to it on the map? You are 3.5 miles 180 degrees due South of the Waypoint. Whenever you want to know where you are on the map pick two grid lines that cross each other on the map. Then enter them into the G.P.S receiver as a Waypoint. Then check your G.P.S to find out where the Waypoint is. You are always 180 degrees and the same distance that is given away from that Waypoint.

One hundred and eighty degrees is a half circle. So 180 degrees will always be exactly the opposite direction. There is a couple of ways to know what 180 degrees is from any given bearing. The easiest way for me is to look at my compass. My Silva type 20 compass has an index line that I set on the bearing for the direction I want to travel. Directly across from this index line is another index line that shows me 180 degrees or the opposite of the direction of travel. Lets say that the G.P.S said that the Waypoint I entered where the two grid lines crossed was 36 degrees 1.5 miles. I would simply set my compass for 36 degrees as if I was going to travel to that Waypoint. I would then look at the index line directly across from 36 degrees that would be set on 216 degrees. I would then know that I was 216 degrees 1.5 miles away from the Waypoint I entered where the two grid lines crossed.

Your compass may not have an index line

telling you the opposite of any given bearing. In that case figure it out with your solar powered calculator. Take whatever bearing your G.P.S says is the direction to the Waypoint where the two grid lines cross and do the following:

            Take any bearing that is between 1 degree and 180 degrees and add 180 to it.
 For example if the G.P.S gives me a bearing of 36 degrees to that Waypoint I would add one hundred and eighty to it. 180 + 36 = 216 degrees. That is 216 degrees is the opposite direction of 36 degrees.

Take any number that is between 181 degrees and 360 degrees and subtract 180.
For example if the G.P.S gives me a bearing of 216 degrees to that Waypoint I would subtract one hundred and eighty from it. 216 -180 = 36 degrees. That is 36 degrees is the opposite direction of 216 degrees.

            Since we keep our G.P.S set to read Magnetic North the 216 degrees is a Magnetic North bearing. Maps however are lined up with True North. Therefore the declination for your area must be included to pinpoint your location on the map.

(8d) Take the amount of declination for your area. Add or subtract this to the reversed 180-degree bearing given by the G.P.S to the Waypoint. In other words we first figured out what 180 degrees is from the bearing given by the G.P.S then we add or subtract the declination from that bearing. (Read "A word about declination" Chapter 6)
            For example lets say I am back in Idaho in the woods outside Post Falls. The G.P.S said that the bearing to the Waypoint I entered was 1.5 miles 36 degrees. I do not want to go to the Waypoint rather I want to know where I am on the map.

I want to know the opposite of 36 degrees. Therefore I add 180 degrees to the 36 degrees that gives me a bearing of 216 degrees. (36 + 180 = 216) The amount of declination must still be added to the 216 degrees. In Post Falls Idaho there is a 19-degree declination that must be added to the Magnetic North bearing. (216 + 19 = 235) So I am 235 degrees 1.5 miles from the Waypoint.

It is not enough for me to know that I am 235 degrees from the Waypoint. I also need to know the exact angle of 235 degrees from that Waypoint to my location on the map. This is where a protractor becomes handy.

As explained in the next step I would take my military protractor center it over the Waypoints' two grid lines. I would measure the 1.5 miles from my map scale and line up the 235 degrees on the protractor and locate myself on the map.

(8e) Use a Military protractor or Declitractor with your ruler to find your location on the map. There are pictures of these and "other protractors" at the end of this chapter.

Unlike the regular protractor that we have all used in school these devices have a complete circle or square measuring 360 degrees. The 360 degrees rotate clockwise. There are cross-hairs in the center that you can line up directly over the Waypoints' two grid lines on your map. The angle we want runs from the center of the cross-hairs to the degree marked on the edge of the protractor.

I also have a plastic ruler that has both standard and metric measurements. I use the metric side for measuring the cm when figuringa G.P.S coordinate. I use the standard side for measuring distance. I would place my ruler on the mile scale in the map legend to know how many sixteenths of an inch are in the distance to the Waypoint. *(Measuring distance is explained more in* Then I would lay my ruler across my military

protractor. I then have a straight edge that is lined up with the cross-hairs and the degree line. The ruler is also my measuring device to measure the distance from the Waypoint to my location. In this way I can pinpoint my location on the map in relation to the Waypoint.

In my example in (8d) the cross hairs of the Military Protractor would be lined up with the two grid lines on the map where the Waypoint was established. The 235 degree line and the cross-hairs on the protractor are then lined up using the ruler. With the ruler I measure the 1.5 miles from the cross-hairs on the protractor to my location along the 235 degree bearing. The point where the 1.5 miles ends is my location on the map.

I prefer to use the Military protractor than just the map and compass alone. I can consistently do a better job locating my exact position on the map using the military protractor and the map. I am not able to be as precise using the map and compass alone.

Once your location is determined using this method you should do the following. Check to see if there is another place where the grid lines cross that is closer to your current location than the one you originally used to establish your position on the map. In the event there is a closer waypoint you can enter to determine your position then repeat the process.

I sometimes find better accuracy by utilizing the gridlines that cross that are closest to my actual location when pinpointing myself on the map.

MILITARY PROTRACTOR
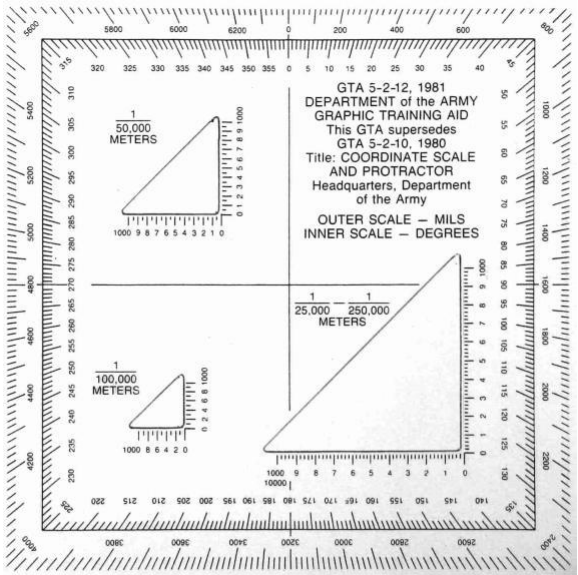
36O Degree Protractor
(Numbers run counter-clockwise)

90 Degree Protractor

Declitractor
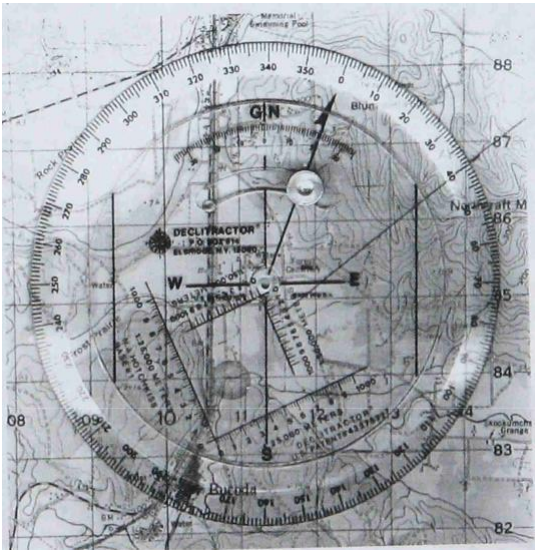
CHAPTER 9
OTHER PROTRACTORS
(See previous illustrations)

You can get by with any protractor. However there may be a few more complications. First of all you will want clear plastic not a colored plastic. You need to line the protractor up on the map's grid lines. Lining up the protractor on the map may cover your Waypoint. You need to be able to see through the protractor to line your ruler up correctly and measure the distance.

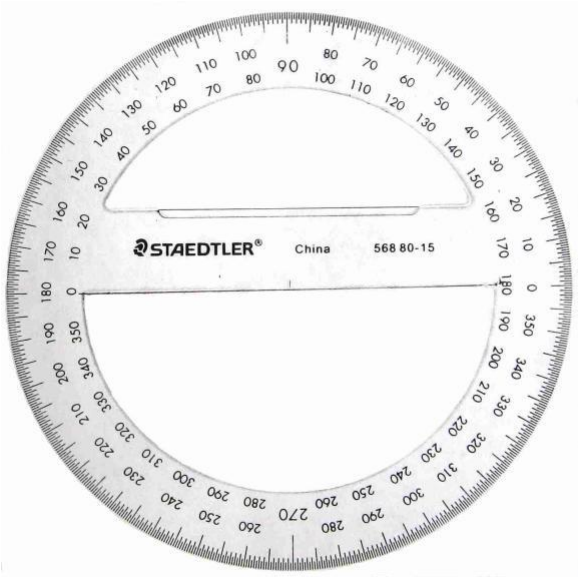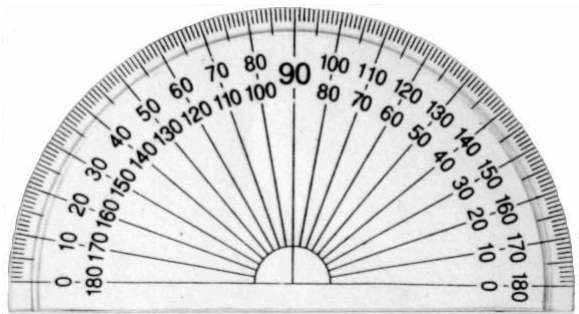**I bought a clear 360 degree protractor at an office supply store.** It was in with the drafting supplies. It cost less than three dollars. It works OK, but there are a couple of things I do not like about it. The numbers on the outside edge go counterclockwise.

The numbers on the compass are arranged clockwise in a circle. Therefore I need the numbers on the protractor to run c lockwise. I can place the protractor face down on the map. Then I can look through the plastic to see the numbers. The numbers would then rotate clockwise as I want, but then the numbers appear backwards. They are still recognizable however. There is a second set of numbers on the inner circle that do run clockwise. However they only go in increments of 10 degrees. One can use the inner circle to get the 10 degrees increments and the outer circles lines for the segments' in-between. One must ignore the numbers on the outside edge in this case and only use the lines to count the degrees past the increment of ten. Another thing I do not like is the outside edge of this protractor has increments of half degrees my compass and G.P.S do not use half degrees. One needs to remember to ignore the smaller lines for this reason.

T   This protractor also does not have good cross hairs to line up on the map's grid lines. However there is a small tick mark in the center for the horizontal grid line. The vertical grid line can be lined up with the 180 and (360) or 0 on the protractor.

My last complaint is this protractor does not fit in my back pocket. It also has thicker plastic than my Military protractor and most of the center is hallow. This does not allow my ruler to lay flat without leaving a gap between the protractor and the map.

Those are my dislikes. However the bottom line is it works. I can use it to locate myself on the map. So if you cannot find a Military protractor at your Army Surplus store as I did then this will work just fine. Just place the protractor face down to make the numbers 1-360 run clockwise. Do not forget (360) or 0 faces the North end of your map when lining up the protractor. The protractors (360) or 0 and 180 are also to be placed directly over the vertical grid line on the map. The tick mark in the center of the protractor is to be placed on the horizontal grid line on the map.

In a pinch you can also use a half circle protractor.

   I have a half circle protractor that the degrees read clockwise. The half circle protractor only has 180 degrees and we need 360. To use this protractor place the arch of the circle facing East on the map.(90 degrees is due East) (East is on the right side of the map.) Line up the 0 and 180 on the vertical grid line. The cross-hairs on the straight ruler part of the protractor should be lined up on the maps horizontal and vertical grid line. One end of your ruler can be placed across the cross-hairs on the straight side of the protractor. The other end of the ruler can be lined up with any degree in-between 1 and 180 degrees.

North

West   90 East

South
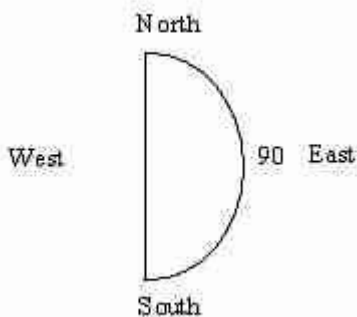
To measure angles 181-360 degrees turn the protractor around with the 90 still facing up so you are not reading the number backwards. Line up the protractor on the grid lines in the same manner as before. The 90 degree is now facing West or the left side of the map. The 180 degree on the outer circle is facing North. The 0 degree on the outer circle is facing South. The angles are correct, but all of the numbers are incorrect. So carry a conversion chart like the one on the next page for measuring anything to the West side of the map. With the protractor placed in this manner the following is true.

(0 = South) (90 = West) (180 = North)

Protractor's	Actual
Degree	Degree
0	180
5	185
10	190
15	195
20	200
25	205
30	210
35	215
40	220
45	225
50	230
55	235
60	240
65	245
70	250
75	255
80	260
85	265
90	270

Protractor's	Actual
Degree	Degree
95	275
100	280
105	285
110	290
115	295
120	300
125	305
130	310
135	315
140	320
145	325
150	330
155	335
160	340
165	345
170	350
175	355
180	360

Why I prefer the military protractor.
(1.) It's cheap.
(2.) It fits in my back pocket.
(3.) The numbers 1-360 go clockwise like my compass.
(4.) It is clear plastic so I can see the map through it.
 (5.) The inside of the protractor is mostly solid so my
        plastic ruler lies flat making it easier to measure.
(6.) The cross-hairs are large making it easy to line up on
      the maps grid lines.

Things to look for in a protractor.
(1)Clear plastic that is easy to see through.
(2) The degrees read clockwise.
(3) There are 360 degrees
(4) The cross-hairs in the middle are easy to see.

CHAPTER 10 Reading your ruler & reading miles on your ruler.

I use a plastic ruler that is a metric ruler on one side and a standard ruler on the other. Many people have difficulty reading a ruler. Therefore I have included this section to help you, if you are one of those people.

The Metric Ruler that I use often throughout this book measures centimeters or abbreviated cm. Each large number on the metric ruler is a centimeter while each large number on a standard ruler is an inch. On the metric ruler the lines in-between are millimeters or abbreviated mm. There is 10 millimeters in 1 centimeter. In the written form numbers to the left of the decimal point are centimeters. Numbers to the right of the decimal point are millimeters. So 1.5 centimeters is 1 centimeter + 5 millimeters. This 1.5 cm is also the same as 15 millimeters. You would locate the number 1 on the ruler and count 5 lines to the right to find 1.5 cm. Starting from the beginning of the ruler there would be 15 lines to find 1.5 centimeters. I use the metric ruler for finding my G.P.S coordinate because it has more lines or parts in a section than the standard ruler would in the same distance. This gives me greater accuracy for establishing my Waypoint.

The other side of my plastic ruler has standard measurements. I have found that the lines on the standard ruler line up better with the mile scale on themap legend. Therefore I use it when I am measuring miles or distance when locating myself on the map. I will include here the breakdown for distance from different map scales that I own. My Standard ruler has 16 parts per inch. You can count the lines on your own ruler to find out what the smallest fraction is on it. The number of lines in one inch would be the bottom number of the fraction. The top number of the fraction would be 1 for one segment.

If the ruler has 16 lines in one inch then each line represents 1/16 inch. I will include the proper fraction as well as the unreduced fraction for those that have trouble reading the standard ruler. That way you can just count the number of parts to know how many miles are in a measured distance.

Most Americans have not become used to relating to distance in kilometers therefore I will only do this for regular miles. Keep in mind that the number to the right of a decimal point will be tenths of a mile. Most of us have become accustomed to tenths of a mile when relating to distance because many cars' odometers read tenths of a mile. The G.P.S receiver also relates distance in tenths and hundredths of a mile.

For this is the reason I end in tenths, hundredths and thousandths of a mile instead of changing the number back into a proper fraction.

The first number to the right of the decimal point is tenths. The second number to the right of the decimal point is hundredths. The third number to the right of the decimal point is thousandths. When doing our calculation of miles to a Waypoint the number 1.875 would represent, 1 mile + 8 tenths of a mile + 7 hundredths of a mile + 5 thousandths of a mile = 1.875 miles. Thinking of it like the odometer on a car it would be rounded of to 1.9 miles (1 mile & 9 tenths of a mile) or almost 2 miles.

My DeLorme Topo map for Oregon has a map scale of 1:150,000. On this map one inch represents 2.4 miles. My standard ruler has 16 parts per inch. So I divided 2.4 by 16 on my calculator and found that each 1/16 of an inch represented .15 miles. Next I added .15 + .15 to find out how much distance was in 2/16 or 1/8 inch. I continued this process until I reached the 2.4 miles that is in one inch on that map.

T

   I always divide the miles by the number of parts in the ruler. <u>Miles divided by parts = the decimal mileage distance per segment on the ruler.</u> In other words this decimal mileage distance represents a fraction. The fraction is the measured distance on the ruler that represents miles and part of a mile.

   I have included several charts for map scales that I own. There is a good chance that you can just use one of the charts for your map. However if your map scale or ruler is not represented here you can use this process to develop the chart needed for your map and ruler. You can also use this process to extend the chart for several inches if you wish.

1 mile divided by 16 parts in ruler =			miles per part
Map Scale 1: 62,500 (1 inch = 1.0 miles)			
Decimal	Sixteenths	Fraction	Miles
	on ruler	on ruler	on map
0.0625	1/16	1/16	0.0625
0.125	2/16	1/8	0.125
0.1875	3/16	3/16	0.1875
0.25	4/16	1/4	0.25
0.3125	5/16	5/16	0.3125
0.375	6/16	3/8	0.375
0.4375	7/16	7/16	0.4375
0.5	8/16	1/2	0.5
0.5265	9/16	9/16	0.5265
0.625	10/16	5/8	0.625
0.6875	11/16	11/16	0.6875
0.75	12/16	3/4	0.75
0.8125	13/16	13/16	0.8125
0.875	14/16	7/8	0.875
0.9375	15/16	15/16	0.9375
1.O	16/16	1 inch	1.O

2 miles divided by 16 parts in ruler = 0.125 miles per part

Map Scale 1:126,720 (1 inch = 2			
Decimal	Sixteenths	Fraction	Miles
	on ruler	on ruler	on map
0.0625	1/16	1/16	0.125
0.125	2/16	1/8	0.25
0.1875	3/16	3/16	0.375
0.25	4/16	1/4	0.5
0.3125	5/16	5/16	0.625
0.375	6/16	3/8	0.75
0.4375	7/16	7/16	0.875
0.5	8/16	1/2	1.O
0.5265	9/16	9/16	1.125
0.625	10/16	5/8	1.25
0.6875	11/16	11/16	1.375
0.75	12/16	3/4	1.5
0.8125	13/16	13/16	1.625
0.875	14/16	7/8	1.75
0.9375	15/16	15/16	1.875
1.O	16/16	1 inch	2.O

2.4 miles divided by 16 in ruler = 0.15 miles per part

Map Scale 1:150,000 (1 inch = 2.4 miles)			
Decimal	Sixteenths	Fraction	Miles
	on ruler	on ruler	on map
0.0625	1/16	1/16	0.15
0.125	2/16	1/8	0.3
0.1875	3/16	3/16	0.45
0.25	4/16	1/4	0.6
0.3125	5/16	5/16	0.75
0.375	6/16	3/8	0.9
0.4375	7/16	7/16	1.05
0.5	8/16	1/2	1.2
0.5265	9/16	9/16	1.35
0.625	10/16	5/8	1.5
0.6875	11/16	11/16	1.65
0.75	12/16	3/4	1.8
0.8125	13/16	13/16	1.95
0.875	14/16	7/8	2.1
0.9375	15/16	15/16	2.25
1.O	16/16	1 inch	2.4

4 miles divided by 16 parts in ruler = 0.25 miles ▮ part

Map Scale	1:250,000(1 inch = 4 miles)		
Decimal	Sixteenths on ruler	Fraction on ruler	Miles on map
0.0625	1/16	1/16	0.25
0.125	2/16	1/8	0.5
0.1875	3/16	3/16	0.75
0.25	4/16	1/4	1.O
0.3125	5/16	5/16	1.25
0.375	6/16	3/8	1.5
0.4375	7/16	7/16	1.75
0.5	8/16	1/2	2.O
0.5265	9/16	9/16	2.25
0.625	10/16	5/8	2.5
0.6875	11/16	11/16	2.75
0.75	12/16	3/4	3.O
0.8125	13/16	13/16	3.25
0.875	14/16	7/8	3.5
0.9375	15/16	15/16	3.75
1.O	16/16	1 inch	4.O

4.8 miles divided by 16 ▮ in ruler = 0.3 miles per part

Map Scale	1:300,000 (1 inch = 4.8 miles)		
Decimal	Sixteenths on ruler	Fraction on ruler	Miles on map
0.0625	1/16	1/16	0.3
0.125	2/16	1/8	0.6
0.1875	3/16	3/16	0.9
0.25	4/16	1/4	1.2
0.3125	5/16	5/16	1.5
0.375	6/16	3/8	1.8
0.4375	7/16	7/16	2.1
0.5	8/16	1/2	2.4
0.5265	9/16	9/16	2.7
0.625	10/16	5/8	3.O
0.6875	11/16	11/16	3.3
0.75	12/16	3/4	3.6
0.8125	13/16	13/16	3.9
0.875	14/16	7/8	4.2
0.9375	15/16	15/16	4.5
1.O	16/16	1 inch	4.8

T

1/16	1/16	0.023
2/16	1/8	0.047
3/16	3/16	0.071
4/16	1/4	0.095
5/16	5/16	0.119
6/16	3/8	0.142
7/16	7/16	0.166
8/16	1/2	0.190
9/16	9/16	0.214
10/16	5/8	0.238
11/16	11/16	0.261
12/16	3/4	0.285
13/16	13/16	0.309
14/16	7/8	0.333
15/16	15/16	0.357
16/16	1 inch	0.380
17/16	1 1/16	0.40
18/16	1 1/8	0.428
19/16	1 3/16	0.452
20/16	1 1/4	0.476
21/16	1 5/16	0.499
22/16	1 3/8	0.523
23/16	1 7/16	0.547
24/16	1 1/2	0.571
25/16	1 9/16	0.595
26/16	1 5/8	0.619
27/16	1 11/16	0.642
28/16	1 3/4	0.666
29/16	1 13/16	0.690
30/16	1 7/8	0.714
31/16	1 15/16	0.738
32/16	2 inches	0.761
33/16	2 1/16	0.785
34/16	2 1/8	0.809
35/16	2 3/16	0.833
36/16	2 1/4	0.857
37/16	2 5/16	0.880
38/16	2 3/8	0.904
39/16	2 7/16	0.928
40/16	2 1/2	0.952
41/16	2 9/16	0.976
42/16	2 5/8	1 mile

1 mile divided by 42 parts in ruler = 0.0238095 miles per part

Map scale 1:24,000 (2 5/8 in = 1 mile)

Left Column = 16ths on ruler
Center Column = Fractions on ruler
Right Column = Miles on Map

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CHAPTER 11

Other navigational tools, things you should bring with you and tips on traveling cross-country.

When I was hiking the Pacific Crest trail I made sure that I had the following items with me. I took some maps a compass, ruler, military protractor, solar powered calculator, pencil, pencil sharpener, paper, rechargeable batteries, small solar panel and of course my G.P.S.

MAPS: There are several different kinds of maps that a person can buy. The good news is now you are no longer limited only to electronic maps. Any map that has the degrees, minutes and seconds along the top and side will work for you. You can even order blown up quadrant maps for your favorite hunting, fishing and hiking areas.

A topographical map is a favorite among many people who love the woods because it adds a 3rd dimension to the map allowing you to see how steep the terrain is. The topographical map can also be used alone to help you determine your location by studying the terrain as compared to the map. You can get a Topographical Atlas and Gazetter for your entire state from DeLorme available in many Sports departments. I got a Coleman Atlas and Gazetter made by DeLorme for Oregon for eleven dollars. It includes grid lines marked with latitude and longitude lines so I can use the paper version for G.P.S coordinates while in the field. DeLorme also has electronic maps for each state.

You can also obtain a variety of topo maps in different map scales. These can be found for each state in the USA by calling:
1-888-ASK-USGS
Or check the following
websites. http://www.usgs.gov/
http://topozone.com/

T Fire maps and Forest Service maps are good for

showing many of the logging roads in the vicinity. I have also found Forest Service maps pretty reliable for finding water sources while hiking. On my old Forest Service maps I had to draw the grid lines in myself, but now the Forest Service has updated most of them to include the latitude and longitude grid lines already included. Forest Service maps are only a few dollars and are available at your local Forest Service. Do not forget to also Check with the Bureau of Land Management (BLM) for maps in the woods also. Sporting good stores and the internet are places you may want to check as well. By looking on the internet I found a map dealer at a local survey supply store. This saved me time from ordering and waiting for my map to come through the mail.

COMPASS: I will not take my G.P.S without also taking my compass. I find it much easier to follow the hand-held compass rather than the compass in the G.P.S receiver. In heavy tree cover the G.P.S will sometimes lose the satellite signal. Yet heavy tree cover does not affect your hand held compass. The hand-held compass still seems easier to follow even when I am not in heavy tree cover. I find it best to get the Magnetic North bearing from the G.P.S and follow that bearing with my hand held compass. Sometimes I even turn the G.P.S off for a while to preserve battery life. Then turn the G.P.S on again just to get an update on the bearing that I am following with the hand held compass.

Note: By using the Magnetic North Bearing from the (G.P.S) I do not set the declination on my compass. I am following a Magnetic North bearing to the Waypoint.

T You will want to remember that metal sources will affect the needle in your compass. The compass is drawn to a magnetic field. Outside sources of metal can cause the floating arrow in the compass to point the wrong way. I once had trouble with mine while working with it on the kitchen table. It took me a while to realize that the metal bar used for extending the table to add a piece was affecting my compass needle. You will always want to consider what metal sources are around the compass while you are working with it. For example I would not recommend laying out our map on the hood of your truck and then trying to also work with your compass there on the hood.

I use a Silva type 20 Compass. Silva has several models of compasses available in many Sports Departments.

A good book to buy to teach you how to use your map and compass together is:
("Be expert with Map & Compass, the complete Orienteering Handbook" by Bjorn Kjellstrom) You can check with your local book store.

Also check my website at **GPSmanual.com** (Note there are no periods between GPS) I will provide updated recommended resources there.

Military Protractor, Declitractor & other protractors:
These tools are a necessity for anybody who wants to measure exact angles of degree on a map to pinpoint their location on a map as explained earlier. I ordered my first Military Protractor through an Army Surplus store. Any protractor that has at least 90 degrees and cross-hairs in the middle to line up on the map will work. You might try looking in places that sell office supplies, school supplies, drafting supplies or survey supplies. Read "Other protractors." (Chapter 9)   Also check my website mentioned above.

T   A good tip using your protractor is to put a piece of thread or light string through the center hole. If there is no hole in the center you can always drill your own. By placing the thread through the hole in the center you can stretch out the end to read the degree or angle anywhere on the map. Of course a thread or small string is easier to carry around than a yardstick or some other object to make a straight line.

The ruler, and solar powered calculators are tools that are cheap, lightweight and necessary to get the accuracy needed in determining coordinates for the G.P.S receiver on a conventional map. You should be able to get a solar powered calculator, a clear plastic ruler with both cm and standard measurements and a protractor without spending a bundle of money.

Altimeters

These devices can measure elevation to an accuracy within 30 feet which is much more accurate than many G.P.S receivers. Using an altimeter and a topo map, which shows the elevation throughout the map, can be an added conformation as to where you are. Be advised that these need to be continually reset since they act like a barometer and are directly affected by weather changes.

Extreme weather

One should consider that many electronic devises such as your G.PS have limits in extreme heat or cold. For those who wish to travel in those conditions they should know what precautions and equipment are needed before departure. This can affect your batteries as well.

I would rather carry a pencil than a pen. You do not have to wonder if the pencil will run out of ink. Also for some reason the pen will not write on certain parts of paper that I have carried in my pocket for a while. With the pencil it does not matter. I also carry a small pencil sharpener with me. Not only will it sharpen your pencil, but also in a pinch the pencil shavings can be used to make fine tinder for starting your fire. Of course I also carry paper to write on, but I need the paper. I do not need the pencil shavings.

Rechargeable batteries and Solar charger. When I was hiking down the Pacific Crest trail I carried several things that used batteries. My G.P.S receiver uses AA batteries. My flashlight uses AA batteries. I carry a Zip stove so that I can cook without caring fuel even during the restricted fire season. The Zip stove uses one AA battery as well. I also carried a cell phone in case of emergency it also runs off a battery. Since I was going to be on the trail for a few months this could be a lot of batteries. So I carried rechargeable batteries and a small 6-inch by 7-inch solar panel to recharge everything. It was made to keep a 12-volt car battery topped off. The solar panel in that respect did not work very well. However it did a great job charging AA batteries and my cell phone. It is just a matter of finding a way to connect the solar panel to the positive end negative points on the batteries. I would charge 4 AA batteries at a time using this solar panel in just a few hours at camp.

T

Tips when traveling cross-country.

Yellow Street signs in the woods. Those that do not live in the 13 original states or Vermont, Maine, Kentucky, Tennessee, West Virginia or Texas have probably seen the little yellow street signs out in the woods. You may not however have known what these signs were. I am talking about survey signs that help surveyors find established corners. Those outside of these areas have probably also noticed that Forest Service maps are divided into little square sections. On the sides of the map there is a T with a number next to it. Next to this number is an N or S. On the top and bottom of the map there is an R with a number next to it. Next to this number is an E or W. The T stands for Township. The R stands for Range, and of course the N, S, E & W stands for North, South, East and West.

A Township is a division of territory in surveys of U. S public land containing 36 sections or 36 square miles. The Range is a means of helping to identify parcels within these sections. Today it is possible to identify a 40-acre tract by referring to a few numbers and symbols using this system.

Keep an eye out for these little yellow signs as you are driving out in the woods. They are only about 4 1/2 inches by 5 inches so you will have to pay attention to find them. The signs along the side of the road will give a bearing and distance to the actual corner. It will also inform you which corner that it is by Township, Range and section. The signs that are closest to the corner will say "Bearing Tree" on the top of the sign. The rest of the sign will have information similar to the following outline.

BEARING TREE

Direction_____   Distance _____
T_____   R_____   Section _____
Corner _____   Tract _____
Posted by _____   Date _____

      The direction and distance are pointing to the actual corner. Most likely it will be a pipe in the ground with a brass cap. On top of the cap it will show which corner it is and the elevation. The T, R and Section are the information that you want.

      The T = Township. The R = Range. Use this like any other map. Find the Township that is on the sign on the side of your map. Then find the Range that is on the sign on the top or bottom of your map. These points come together at a group of 36 squares each with a number in the center. Each one of these squares is a square mile. The number in the center of the square is the "Section." This sign is telling you the direction and distance to a corner post of that section on your map.

      Keep in mind when finding where the two points of Township and Range come together is a wide strip. The 36 squares within a Township are six squares by six squares. You will be looking in a strip that contains three squares to both sides of the Township and three squares to each side of the Range. Where these two strips meet is a 36 square section where you are looking for the section number that was on the yellow sign.

      We have worked with Dollar Mountain earlier, which is on the map at the back of this book. Dollar Mountain is located in T 36 S, R 6 W, Sec. 12. That is Dollar Mountain is located in Township 36 South, Range 6 West, Section 12.

T In this case the Township 35 South and the Range

6 West does not show 3 squares to each side because it is the edge of the map. The 35 South is placed in the correct spot. The Range 6 West is out of place because Range 6 West sections 15 & 16 are not on the map. State boundaries are another example that will also throw the sequence off. The following illustration may be of some help.

Each 36 square section
is laid out in the following manner.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Lines' in-between the actual corners are sometimes marked. They are marked by blazing or cutting into a tree and painting that spot with red paint. Then periodically there will be a larger yellow sign that says "Property Boundary National Forest Land behind this sign."

Sometimes you will see other little yellow signs along side of the road that do not say "Bearing Tree." These signs contain the same information of Township, Range and Section that you need. The difference is that the actual corner is farther away. The "Bearing Trees" are all close to the corner. These other yellow signs are not real close to the corner, but they help the surveyor to know where to park and start walking cross country to the corner.

Other times you will see stakes or post with a BM on it and Elev. and a number. The BM stands for bench mark. The Elev. is the elevation. This can be of some help if you are using a Topographical map.

You may want to find some of these useful little yellow signs to become familiar with them. You can look on your map to see where some section corners are close to a road in which you are familiar. Use the first part of this book to figure out what the coordinate is to those corners. Then you can enter them into your G.P.S receiver and go out and find them. When you find the corner you can pretend you are lost and practice locating yourself on the map using your G.P.S and protractor.

Do not try to hit a trail head on when looking for it.

Lets say you are hiking down a trail. Suddenly the trail disappears under a blanket of snow. You can look for blazed or cut trees. These would be signs that you are still on the trail even though you can no longer see it. There will however be times when you see no sign of the trail ahead of you at all. You can use the skills you learned in this book to take a coordinate on the trail ahead of you from the map. However a hiking trail is only a couple of feet wide. It is possible to only be a short distance off the trail and not be able to see it because of trees and brush. The coordinate that you establish ahead of you may not put you on that 2 ft path if you try to hit it head on. To over come this you can enter a coordinate that you know is actually to the right of the trail and enter that into the G.P.S as a Waypoint. Now when you reach that Waypoint you know that the trail is actually to your left. Then make a 45 degree turn to the left. This will cause you to actually cross the trail. This is an easier way to find it then trying to hit it head on. This process can of course also be used to hit roads, creeks, rivers or anything long and narrow.

There will be times when you are trying to locate other things. You may arrive at the Waypoint that you entered from the map and not be able to see what you are looking for right away. That does not mean that it is not near by. Think for a moment what might be obstructing your view? I remember when I first started to learn how to use my G.P.S receiver. I entered my van as a Waypoint and then walked away. I was so focused on the G.P.S and compass that I did not really pay any attention to where I was going. I tried going back to the van and arrived at my Waypoint, but could not see the van. I remember thinking "great this stupid thing doesn't work! Now where in the heck am I?" I walked about 100 feet and noticed my van parked behind a little hill. The hill was just tall enough to keep me from seeing the van. So stop and think before you assume you are lost. Do not panic even if you did mess up on your coordinate and become lost you can always use your G.P.S and protractor to find yourself on the map again and start over.

Remember to look for signs of your desired destination. Were you looking for a small pond that you have never been to before? Could it be dried up? Were you looking for a creek? Is there a ravine nearby that you cannot see the bottom? Were you looking for a mineshaft? Do you see any tailings? (Tailings are rocks taken out of the mine) Think and look around before you give up!

This would also be a good time to use your G.P.S and protractor to verify your location on the map. This could give you a clue of how close you are and which way to go from there. In actual practice I have often found that my bearing was correct while the distance may have been slightly off.

You can estimate your bearing using a stick.

You never know when your G.P.S may malfunction or when you may lose your compass. It is always good to know other ways to determine direction. You can find the general bearing with a stick and a couple of small rocks. You will also need enough sunlight or moonlight to cast a shadow. Push the stick into the ground as vertical as possible. Place a small rock at the end of the shadow cast by the stick. Now wait 10 to twenty minutes for the shadow to move. Place a second rock at the end of the shadow cast by the stick. A line drawn between the first rock and the second rock will point East and West in the Northern Hemisphere. The first rock is on the West end of the line. The second rock is on the East end of the line. In the middle of the day this line will be pretty close to West. In the morning it will point slightly South of West. In the afternoon it will point slightly North of West.

The sun and moon appear to travel from East to West. The shadows created by both the sun and the moon travel from West to East. The shadow is the opposite. You now have an idea which direction is East and West. I want you to now picture a map of the USA in your mind. If you are facing North the East coast is on your right hand side and the West coast is on your left.

T Position your body so that you are facing North.

Now imagine in your mind that you are standing in the center of a huge clock with hands. 12 o'clock is due North. The numbers 1 through 12 on this clock are all 30 degrees apart.

12 o'clock = 360 degrees - North
1 o' clock = 30 degrees
2 o' clock = 60 degrees
3 o'clock = 90 degrees - East
4 o' clock = 120 degrees
5 o'clock = 150 degrees
6 o'clock = 180 degrees - South
7 o'clock = 210 degrees
8 o'clock = 240 degrees
9 o' clock = 270 degrees - West
10 o'clock = 300 degrees
11 o'clock = 330 degrees
12 o'clock = 360 degrees - North

Granted this is not near as precise as your compass and G.P.S, but it will give you a general idea which direction any bearing is from where you are standing.

Hunters check in using a radio and give your coordinate to your partner.

Often hunters carry a two-way radio. It would be a good idea to agree ahead of time to check in with each other once every hour and exchange your coordinate with each other. Then if something does happen they will at least know where to begin looking for you. Even if for some reason you were unconscious your search party could narrow down where to look for you to a relatively small area. Your last coordinate would be a good place for a rescue dog to pick up your scent.

Your partner should at least know how to turn the G.P.S on and read the coordinate to call 911.

Your partner should know how to turn the G.P.S on even if they do not know how to do anything else. Explain to them that when the G.P.S finds itself it displays the coordinate of your location. This information and a cell phone could save someone's life. It is worth the couple of minutes that it will take to show everybody in the group including children.

How to locate a G.P.S coordinate on a paper map.

Suppose you do get a radio message or phone call and someone is hurt. They give you a G.P.S coordinate of the victim. You can enter that coordinate into the G.P.S receiver and start in a direct bearing to it. However that may not be the best route. Perhaps there is a road near them that would be a better starting point before heading cross-country. You can take the G.P.S coordinate that was given and locate that position on the paper map first to help determine the best route to get there.

1. Enter the coordinate given as a Waypoint into your G.P.S receiver.
2. Get the bearing and distance to that Waypoint from the G.P.S receiver. Since we keep our G.P.S set on Magnetic North add your declination to that bearing.
3. Locate yourself on the map as covered in chapter 8
4. Place a dot on the map at your actual location.
5. Place the cross hairs of the protractor directly over this dot you just made. Make sure the protractor is as straight as possible as, if the cross hairs were centered over two grid lines.
6. Place your ruler on the cross-hairs of the protractor and the bearing that includes the declination and measure the distance to the victims location. Place an X there and start planning the best route to get to them.

T

You can use your protractor to get a compass bearing.

From a known location on the map you can obtain a bearing and distance to another point on the map using your protractor and ruler. Place the crosshairs of your protractor over your current position on the map. Place your ruler over the crosshairs and your desired location. Measure the distance in between the points with your ruler. Here in Oregon I have been adding the declination to change to Magnetic North from my G.P.S to True North on the map. Now I would subtract the declination from True North on the map & protractor for Magnetic North for the compass.

Lets say that you figured a coordinate from the map for your G.P.S Receiver and entered it as a Waypoint. You could also use this method to verify your accuracy by making sure the bearing and distance are the same using both methods.

When saving a Waypoint of your current position check to see the distance to it before you move on.

Usually the current position will have a distance to it. In other words you did not actually save the position where you were standing when you saved the Waypoint. Rather you saved a position nearby. This is normal and not a problem. However once in a while the distance to the position is greater than .02 miles. In that case I would delete the Waypoint and save it again before I moved on. Otherwise I would miss it by a greater distance when I tried to return to that Waypoint.

WHAT TO EXPECT IN THE FIELD

I wish I could tell you that you will always find your waypoint within 100 feet. However that isn't going to happen. Let me tell you about my first time I tried to go to Dollar Mountain. I had first figured out the G.P.S coordinate that is here in this book. I saw on a county map that "B" street in Grants Pass would take me close to the base of the mountain. When I got to the end of "B" street I was looking at a gate across the road and several No Trespassing signs. I turned on my G.P.S and asked it where Dollar Mountain was. It gave me a bearing and a distance. I then used my compass to point myself in the direction of that bearing. It pointed directly at a large antenna on top of a mountain. I reasoned that I could try to circle around the mountain using the antenna for reference point. I wanted to find a way to access the mountain without trespassing.

I drove a short distance up another road off of ""B" street and I saw a sign that said "Trail head" I stopped the truck and checked to see if the trail went in the same direction that I wanted to go. When I verified that the trail was going the right way I parked and started heading up the trail. A short way up the trail it took a sharp turn and was no longer heading toward Dollar Mountain. I left the trail at that point and used my G.P.S and compass to head directly toward it. When I was getting close to the top of the mountain I hit the trail again. When I reached my coordinate I was on the South side of the mountain below the antenna, but I was not on top of the mountain.

I then used my G.P.S and protractor to verify where I was on the map. It placed me on the South side of Dollar Mountain near the top. Since I verified that I was indeed on Dollar Mountain I went ahead and walked 400 more steps to reach the top of the mountain. None of my maps showed the tower on top of Dollar Mountain or the trail going up to it. Still I found it just the same.

Some friends thought that my trip was a failure when I first told them I missed the top. That is because they think in terms of the G.P.S always bringing them within mere feet of the destination. However experience shows a person they can save a position with the G.P.S when actually there. Then later traveling back to the same spot they often will not hit the spot right on the money, but they will be close. Figuring the G.P.S coordinate from the map before going there or pinpointing yourself on the map will usually have a greater degree of error than actually being there first and saving the coordinate.

An electronic map will often give you a coordinate that is closer than using the methods in this book. Yes my electronic version showing Dollar Mountain missed the actual top as well, but it was closer. My friends' electronic version missed the top as well. The point is that there are many good paper maps out there that show detail that is not on an electronic map.

Without utilizing skills similar to what is in this book a person could not use their G.P.S to go there at all because they would not know a coordinate to enter into their G.P.S receiver.

For example Lets say I wanted to go to Big Bald Spot, Little Bald Spot or the creeks around Bear Pen Gap all which are found to the East of Grants Pass Peak on my forest service map. I would not be able to use my G.P.S to find them without the skill as described in this book. The Delorme Topo electronic map I have of that area does not show these features seen on my forest service map. By using the skills taught in this book I am not limited to electronic versions of maps. This skill allows a person to use any of their favorite paper maps that provide Latitude and Longitude on the sides of the map.

The Most things you will look for will not be like trying to find a stake driven in the ground somewhere. Mountains, lakes and ponds are big enough you can find them once you arrive in the general vicinity. Roads, trails and creeks can always be found by figuring a coordinate to the side of it then making a 45 degree turn to cross it as described earlier. Plan your coordinate well enough and you will also know which way to turn when you do hit the road or trail. Truthfully if I land within a thousand feet of my destination I can usually find what ever it was that I set out to look for. So the bott om line is I can use any map I want and always find what I am looking for or locate myself on the map. Just don't expect to always land within 20 feet of your destination. That simply is not going to happen. Of course larger map scales and more parts on the ruler can help me to increase my accuracy, but that does not mean that I need to run out and buy another map to find something I can already see on the map I have.

One can use other skills to return to an exact location if so desired. For example when I hiked the Pacific Crest Trail across Oregon I first buried food at locations where the trail crossed major roads and highways. I placed my dried food in waterproof containers. I used my G.P.S coordinates and maps to find where the trail crossed these roads and highways. I then looked for something unusual that would make sense in my notes. For example if I seen a Cedar Tree with two different tops on it I would take a G.P.S coordinate there and make a note to look for the Cedar Tree with two tops. Then I would state something like. From the Magnetic North side of the tree set the compass for 216 and measure 16 of my shoe lengths and dig down under the quartz rock. I found all of my drops in this manner.

I also found the trail a few times after loosing it in the snow by following he methods in this book. I even used the methods in this book to find creeks to get water that did not actually cross the trail. Use your own power to reason and several different tools like maps, compass, G.P.S etc. and you will soon gain the confidence that you can indeed travel anywhere you want cross-country and not get lost. Make sure you read as well.
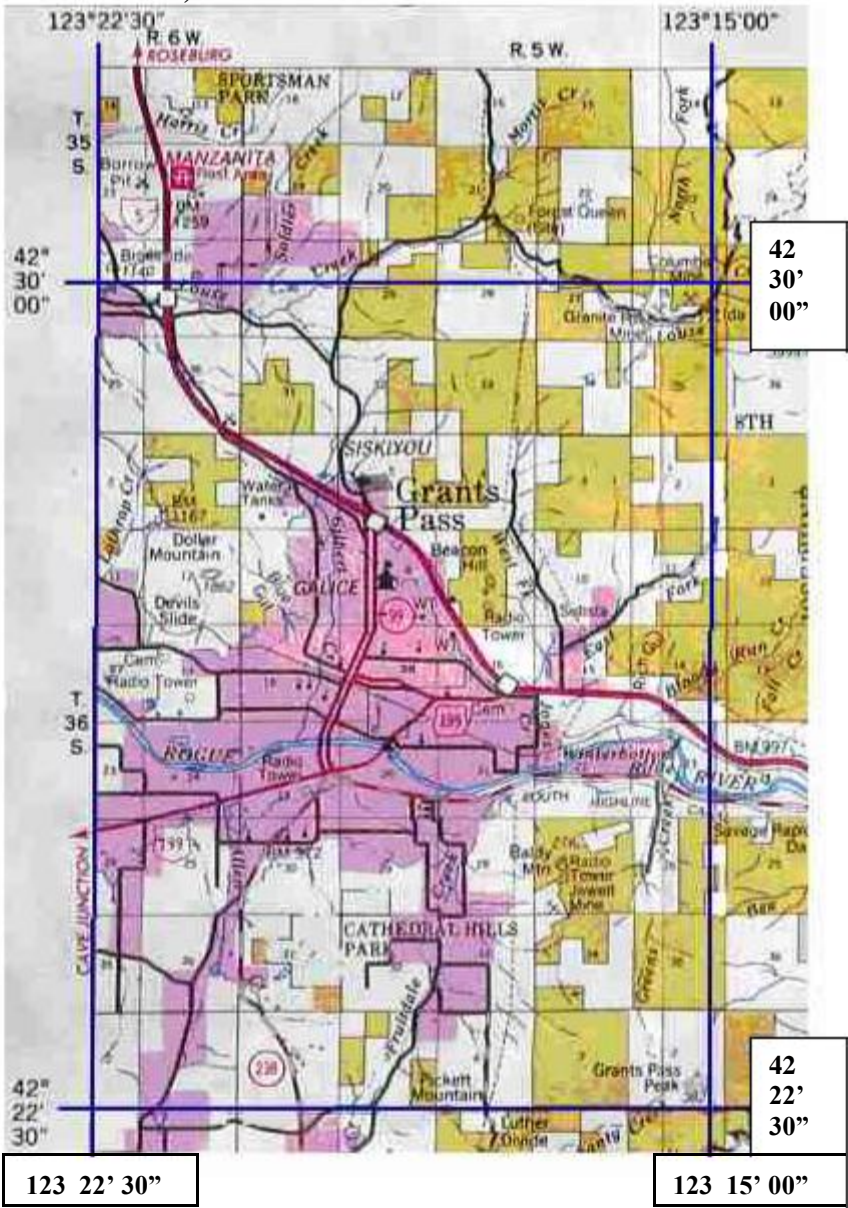
As with most things in life the more you know and understand the more successful you will be when applying your knowledge to the task at hand. Well have fun and remember be safe! Practice first in areas you already know.

Rouge River National Forest

Scale 1:126,720 **1 inch = 2 miles**

42
30'
00"

42
22'
30"

123 22' 30"   123 15' 00"

NOTE FROM THE AUTHOR

I had no book or person to teach me how to do this. I do not consider myself an expert in the field of navigation, map making or math. I cannot guarantee that this book is free from all errors. Even I would not risk my life only on the content of this book. Therefore you should not either!

I can say that I have used the methods that I described in this book for several years and I have encountered some problems and I believe I have the bugs worked out, but I cannot guarantee that to be true.

I believe that using the methods in this book along with other navigational skills such as good map reading and compass skills will prove to be useful to all who are interested in cross-country travel. No single method of navigation by itself should be relied upon as the only means of knowing where you are going or where you are.

I would remind you to practice first in familiar areas. Do this both for finding a coordinate and locating your position on the map. Even when lost redoing this a couple of times while probably solve your problem.

The main key is even, if you do become lost to keep a level head. Do not panic! Stop, if necessary prepare camp. Fumbling around in the dark is a good way to make matters far worse. Nobody dies because they are lost, but you can die from hypothermia even on a summer night in just a few hours. Here your survival skills and thinking clearly are far more important than being a good navigator!

I recommend everybody becomes familiar with more than one form of navigation, survival skills and emergency first aid before attempting any cross-country travel in the wilderness. Be prepared for the worst so that you can enjoy the best!

Anybody can do this!!

- The professor
- The old hunter
- The not so dumb blonde
- Even the Author can do this!
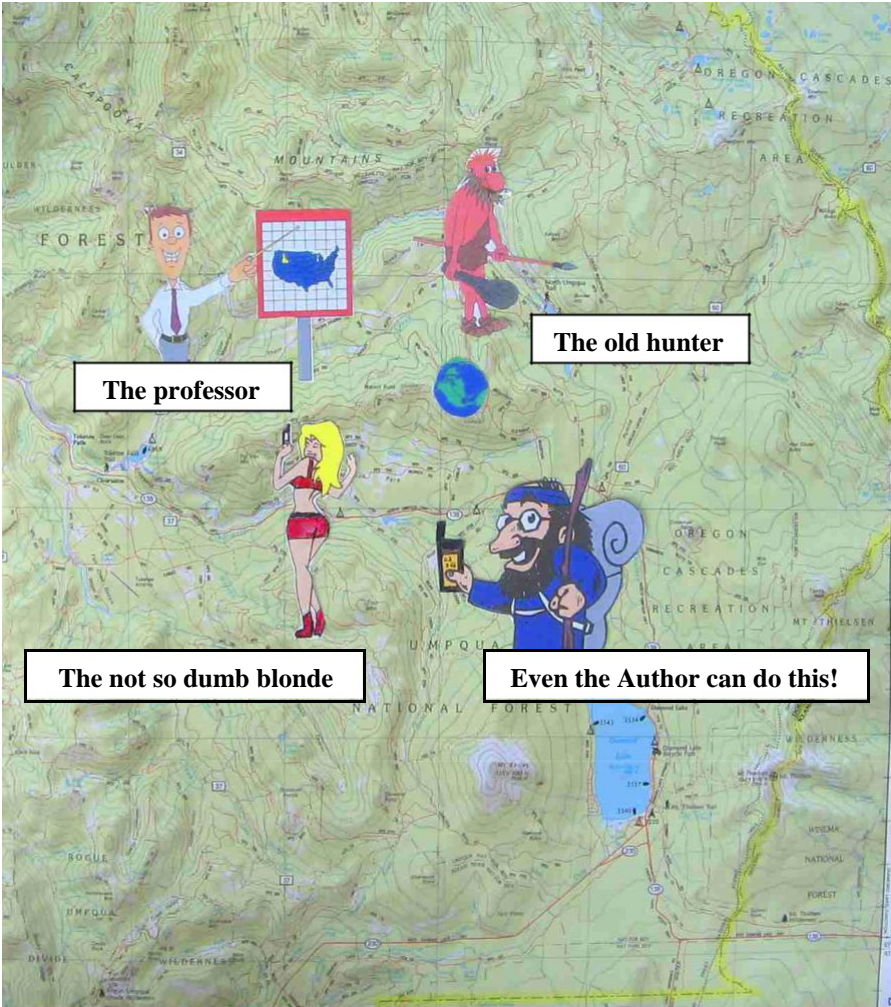
1. Go anywhere using the cheapest G.P.S
2. Don't be limited only to electronic maps.
3. Save Money! Don't buy stuff you don't need.